TMDL Development for Dissolved Oxygen and Nutrients for Bayou Lafourche Subsegment (020401) in the Barataria Basin, Louisiana

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EXECUTIVE SUMMARY

Section 303(d) of the Federal Clean Water Act requires states to identify waterbodies that are not meeting water quality standards and to develop total maximum daily loads (TMDLs) for those waterbodies. A TMDL is the amount of pollutant that a waterbody can assimilate without exceeding the established water quality standard for that pollutant. Through a TMDL, pollutant loads can be distributed or allocated to point sources and nonpoint sources discharging to the waterbody. This report presents TMDLs that have been developed for dissolved oxygen (DO) and nutrients for Bayou Lafourche (Subsegment 020401) in the Barataria Basin in central Louisiana.

Subsegment 020401 is located in the Barataria-Terrebonne National Estuary in southeastern Louisiana and extends from Donaldsonville to the Intracoastal Waterway (ICWW) at Larose. This subsegment of Bayou Lafourche is approximately 69 miles long and has a drainage area estimated at 10 square miles. The primary source of flow through Bayou Lafourche is provided by the Mississippi River as pumped through the Walter Lemann, Sr. Pumping Station at Donaldsonville at an average flow rate of 200 cubic feet per second (cfs). Land use in the subsegment is primarily agricultural (sugar cane cultivation) and urban/residential. There are numerous point source discharges, but they are typically small sanitary wastewater discharges.

Bayou Lafourche Subsegment 020401 is identified in the Modified Court Ordered 303(d) list as not meeting DO and nutrient criteria. The suspected sources of oxygen depletion and nutrients in Bayou Lafourche are defined in the Louisiana 303(d) listing as minor municipal point sources, package plants (small flows), collection system failure, inflow and infiltration, domestic wastewater lagoons, land disposal, septic tanks, other natural and unknown sources, flow regulations and/or modifications, and minor industrial point sources. Designated uses for Bayou Lafourche Subsegment 020401 include primary and secondary contact recreation, propagation of fish and wildlife, and drinking water supply. The water quality standard for DO in this subsegment is 5 milligrams per liter (mg/L) year round.

Louisiana has no numeric standards for nutrients in waterbodies but does have a narrative standard which requires that the naturally occurring range of nitrogen-phosphorus ratios be maintained. For the purpose of this TMDL, nutrients included total nitrogen (organic nitrogen, ammonia nitrogen, and nitrite plus nitrate nitrogen) and total phosphorus (TP). An evaluation of the nutrient ratio was performed on water quality data from the Bayou Lafourche monitoring stations. The calculated ratio was determined to be about 11:1. This ratio is supported by available reference stream data for the Upper Mississippi Alluvial Plain and South Central Plain ecoregions of 10:1 (Smythe, 1999).

A water quality model (LA-QUAL) was used to simulate DO, carbonaceous biochemical oxygen demand (CBOD), ammonia nitrogen, and organic nitrogen in the subsegment. The model was set up and calibrated using intensive survey data collected on September 23, 2003, U.S. Geologic Survey (USGS) real-time monitoring station data, Louisiana Department of Environmental Quality (LDEQ) routine monitoring data collected during 1997 and 1998, and other various information obtained from LDEQ and USGS. The projection simulations were run at critical flows and temperatures to address seasonality as required by the Clean Water Act. The modeling in this study was consistent with guidance in the Louisiana TMDL Technical Procedures (LTP) manual.

The projection simulation results were used to develop a TMDL for oxygen demanding substances (CBOD, ammonia nitrogen, organic nitrogen, and sediment oxygen demand [SOD]) under the following scenarios:

- Scenario 1 – Current loading scenario, including all point sources, nonpoint sources, and natural background contributions;

- Scenario 2 – Modified loading scenario, as necessary to meet the 5.0 mg/L DO standard, through the increase/reduction of all existing loading (point sources, nonpoint sources, and natural background contributions) until the DO standard is met;

- Scenario 3 - Modified nonpoint source loading scenario, as necessary to meet the 5.0 mg/L DO standard, through the increase/reduction of all existing nonpoint source loading and natural background contributions until the DO standard is met;

- Scenario 4 – Modified flow scenario, utilizing a minimum flow (Scenario 4a) to achieve the 5.0 mg/L DO standard in the extant model developed under the first three scenarios, and a projected flow of 1,000 cfs for the subsegment without the fixed weir at Thibodaux and increased cross-sectional areas due to anticipated dredging (Scenario 4b); and

- Scenario 5 – Loading evaluation scenario, utilizing the extant model developed under the first three scenarios that demonstrates the relative impact of various loading through the elimination of all point source loading (Scenario 5a) and elimination of all nonpoint source loading (Scenario 5b).

Calculated Load Allocations (LA), Waste Load Allocations (WLA), Margin of Safety (MOS), and TMDLs for Scenarios 2, 4a, and 4b are presented below. A discussion of the results for each scenario is provided in subsequent text. The largest loading to Subsegment 020401 is the constituency of waters diverted from the Mississippi River. For purposes of this TMDL, the constituency of the Mississippi River waters is considered to be a nonpoint source loading.

Calculated Load Allocations, Wasteload Allocations, Margins of Safety and TMDLs under Scenarios 2, 4a, and 4b for Summer and Winter Conditions

Load Description	Summer (May-Oct) Scenario 2	Summer (May-Oct) Scenario 4a	Summer (May-Oct) Scenario 4b	Winter (Nov-Apr) Scenario 2	Winter (Nov-Apr) Scenario 4a	Winter (Nov-Apr) Scenario 4b
Current Point Source Loadings at Critical Conditions (kg/d of UOD)	533	533	533	396	396	396
Current Nonpoint Source Loadings at Critical Conditions (kg/d of UOD)	3,053	3,053	3,053	3.053	3,053	3,053
Maximum Nonpoint Source Loadings at Critical Conditions (kg/d of UOD)	20,009	835	108,666	31,550	810	157,786
Point Source WLA (kg/d of UOD)	533	533	533	396	396	396
Nonpoint Source LA (kg/d of UOD)	17,955	835	97,746	28,355	810	141,968
10% MOS (kg/d of UOD)	2,054	0	10,920	3,195	0	15,818
Assimilative Capacity (kg/d of UOD)	20,542	1,368	109,199	31,945	1,206	158,181
Reserve Capacity (kg/d of UOD)	14,902	0	94,693	25,302	0	138,915
TMDL (kg/d of UOD)	20,542	1,368	109,199	31,945	1,206	158,181
TMDL (lbs/d of UOD)	45,287	3,015	240,739	70,426	2,658	348,724
% Reduction in Nonpoint Source Loading Required	0	0(1)	0	0	0(1)	0
% Reduction in Point Source Loading Required	0	0	0	0	0	0

(1) Nonpoint source loading reduction results from headwater flow reduction, thus no reduction of nonpoint source loading is required along the 108 kilometers of the bayou subsegment.
kg/d = kilograms per day
lbs/day = pounds per day
UOD = sum of $CBOD_u$ and $NBOD_u$

All projected simulations indicated that the ambient concentrations of ammonia nitrogen (maximum concentration of 0.14 mg/L) would be below the chronic criteria as determined under the 1999 updated criteria (minimum concentration of 1.44 mg/L). The results of the model projection simulations under each scenario are summarized as follows:

Scenario 1 – Under existing loadings, the projected summer critical conditions (7Q10 flow and temperature of 30.27° Celsius [C]) and winter critical conditions (7Q10 flow and temperature of 20.80°C) maintained the 5.0 mg/L DO standard throughout the reach of the subsegment. Therefore, no load reductions will be required under this TMDL. An explicit 10 percent margin of safety was included in the TMDL calculations.

Scenario 2 – Because no load reductions were required under summer or winter critical conditions in Scenario 1 to maintain the 5.0 mg/L DO standard, the results of Scenario 2 show how much ultimate oxygen demand, UOD (sum of CBODu and ultimate nitrogen biochemical oxygen demand (NBODu)) loadings can be increased above current loadings while maintaining the 5.0 mg/L DO standard.

Scenario 3 – Because no nonpoint source load reductions were required under summer or winter critical conditions in Scenario 1 to maintain the 5.0 mg/L DO standard, the results of Scenario 3 are the same as from Scenario 2.

Scenario 4 – Two flow regimes were evaluated under this scenario: a minimum diversion from the Mississippi River that maintains the 5.0 mg/L DO standard (Scenario 4a) and a maximum anticipated diversion of 1,000 cfs (Scenario 4b). At fully anticipated point source and nonpoint source loading, a minimum flow of 2.1 cfs was determined to be the minimum flow necessary to maintain the 5.0 mg/L DO standard in summer. The 5.0 mg/L DO standard would be maintained in winter even at zero flow.

At the maximum anticipated diversion of 1,000 cfs, no load reductions were required for summer critical conditions (7Q10 flow and temperature of 30.27°C) or for winter critical conditions (7Q10 flow and temperature of 20.80°C) to maintain the 5.0 mg/L DO standard. An explicit 10 percent margin of safety was included in the TMDL calculations.

Scenario 5 – Because no load reductions were required for summer and winter critical conditions under Scenario 1, the load reductions in Scenarios 5a and 5b simply illustrate the relative impacts of loading types on hypothetical projections. Headwater loadings to the subsegment were not eliminated under either Scenario 5a or 5b. Under both summer and winter critical conditions, the impact of eliminating point sources to instream DO concentrations is minimal when compared to the results from Scenario 1. This observation underscores the small contribution of oxygen-demanding substances from existing point sources in the subsegment. The impact of eliminating nonpoint sources, other than the Mississippi River diversion, on projected instream DO concentrations was also minimal. Slight increases in instream DO concentrations (<0.3 mg/L) were apparent for that portion of the subsegment upstream of the Thibodaux weir (River Kilometer [RK] 54.0).

Much of coastal Louisiana was built by the process of delta formation through flooding and deposition of sediments by the rise and fall of the Mississippi River. Based on EPA's present knowledge, extensive areas of wetlands and coastal marshes are affected by a high rate of subsidence and degradation, primarily due to a lack of historical sediment and nutrients entering the wetlands. Subsidence is a natural process, but the building of levee systems has restricted the Mississippi River's course therefore preventing the natural cycle of the river and the natural process of delta formation. According to EPA, a large portion of the state's coastal wetlands have undergone and continue to undergo a severe deprivation of sediments and nutrients that has led quite literally to the breakup of the natural system. In addition, EPA believes that many of Louisiana's wetlands have become isolated from the riverine sources that created them and are becoming stagnant and starved for nutrients and organic and inorganic sediments. It should be pointed out that restoration of these eroding wetlands involves supplying nutrients to these wetlands through managed Mississippi River diversions.

The proposed TMDL for DO and nutrients for Bayou Lafourche presents a modified flow scenario, Model Scenario 4b. The modified flow of a 1,000 cfs diversion from the Mississippi River into Bayou Lafourche resulted in no required load reductions to maintain 5 mg/L of DO during summer and winter critical conditions as reported in Section 4. The Bayou Lafourche reintroduction proposed under the Louisiana Coastal Area, Louisiana, Ecosystem Restoration Study (LCA Study), could range from 1,000 to 5,000 cfs. EPA believes that flows greater than 1,000 cfs will result in flow increases that will enhance DO and decrease the likelihood of instream nutrient impairment in Bayou Lafourche. Based on EPA's calculations, if the proposed diversion from the Mississippi River into Bayou Lafourche approaches 5,000 cfs, the non-point source load allocation and TMDL for Model Scenario 4b will also be increased by 390,894 kg/day of UOD for the summer and 567,872 kg/day of UOD for the winter, respectively (EPA, 2005).

Based on EPA's current understanding, these diversion projects are supported by both State and Federal agencies, including EPA and the U.S. Army Corps of Engineers. The diversions are managed by the Corps of Engineers and the State, and the projects include post-diversion monitoring to determine effectiveness of the project and to monitor water quality conditions.

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Abbreviations and Acronyms

BASINS	Better Assessment Science Integrating Point and Nonpoint Sources
BOD_5	5-day biochemical oxygen demand
BOD_U	Biochemical oxygen demand ultimate
$CBOD_{20}$	20-day biochemical oxygen demand
CBOD	Carbonaceous biochemical oxygen demand
$CBOD_U$	Carbonaceous biochemical oxygen demand ultimate
cfs	Cubic feet per second
cms	Cubic meters per second
COD	Chemical oxygen demand
DO	Dissolved oxygen
DQO	Data quality objectives
EDMS	Electronic Document Management System
EPA	Environmental Protection Agency
HEC-RAS	Hydraulic Engineering Center - River Analysis System
ICWW	Intracoastal Waterway
kg/d	Kilograms per day
Km	Kilometers
LA	Load allocation
LAIS	Louisiana Agriclimate Information System
lb/d	Pounds per day
LDEQ	Louisiana Department of Environmental Quality
LPDES	Louisiana Pollutant Discharge Elimination System
LTP	Louisiana Total Maximum Daily Load Technical Procedures
m/day	Meters per day
mg	Milligram
MOS	Margin of safety
mg/L	Milligrams per liter
NBOD	Nitrogen biochemical oxygen demand
NH_3-N	Ammonia nitrogen
PCS	Permit Compliance System
QAPP	Quality Assurance Project Plan
RK	River kilometer

SOD	Sediment oxygen demand
TKN	Total Kjeldahl nitrogen
TDS	Total dissolved solids
TOC	Total organic carbon
TP	Total phosphorus
TSS	Total suspended solids
TMDL	Total Maximum Daily Load
µg	micrograms
µg/L	Micrograms per liter
UOD	Ultimate oxygen demand
USGS	United States Geological Survey
WLA	Wasteload allocation

1.0 INTRODUCTION

This report presents total maximum daily loads (TMDLs) for dissolved oxygen (DO) and nutrients for Subsegment 020401 (Bayou Lafourche from Donaldsonville to the Intracoastal Waterway [ICWW] at Larose). The 1999 Louisiana court-ordered 303(d) list includes subsegments that do not meet DO standards and for which TMDLs have not been established. In many previous cases of DO impairment, data indicate that nutrients, including ammonia, might be contributing to this non-attainment. Development of the TMDLs involves assessing existing data, conducting a field survey, selecting and calibrating a model, evaluating pollutant sources, and formulating TMDLs, including a load allocation (LA), wasteload allocation (WLA), and margin of safety (MOS). All reasonable efforts have been taken to utilize previous modeling efforts of the Louisiana Department of Environmental Quality (LDEQ) and the U.S. Environmental Protection Agency (EPA) in establishing TMDLs in this Basin.

The purpose of a TMDL is to determine the pollutant loading that a waterbody can assimilate without exceeding the water quality standard for that pollutant and to establish the load reduction that is necessary to meet the standard in a waterbody. The TMDL is the sum of the WLA, the LA, and an MOS. The WLA is the load allocated to point sources of the pollutant of concern, and the LA is the load allocated to nonpoint sources. The MOS is a percentage of the TMDL that accounts for the uncertainty associated with the model assumptions, data inadequacies, and future growth.

This TMDL report represents a revision to a previously proposed TMDL report developed for the Bayou Lafourche subsegment. In response to comments developed by LDEQ, EPA requested that several additional projection scenarios be evaluated under this project. These scenarios include:

- Scenario 1 – Current loading scenario, that includes all point sources, nonpoint sources, and natural background contributions under critical streamflow and temperature conditions for summer and winter seasons;

- Scenario 2 – Modified loading scenario, as necessary to meet the 5.0 mg/L DO standard, through the increase or reduction of existing loading (point sources, nonpoint sources, and natural background contributions) until the DO standard is met;

- Scenario 3 – Modified nonpoint source loading scenario, as necessary to meet the 5.0 mg/L DO standard, through the increase or reduction of all existing nonpoint source loading and natural background contributions until the DO standard is met;

- Scenario 4 – Modified flow scenario, utilizing a minimum diversion from the Mississippi River (Scenario 4a) to achieve the 5.0 mg/L DO standard in the extant model developed under the first three scenarios, and a projected diversion of 1,000 cfs from the Mississippi River for the subsegment without the fixed weir at Thibodaux and increased cross-sectional areas due to anticipated dredging (Scenario 4b); and

- Scenario 5 – Loading evaluation scenario, utilizing the extant model developed under the first three scenarios that demonstrates the relative impact of point and nonpoint loading through the elimination of all point source loading (Scenario 5a) and elimination of all nonpoint source loading (Scenario 5b).

This report provides the results of the requested efforts.

2.0 STUDY AREA DESCRIPTION

2.1 General Description

Bayou Lafourche is located in the Barataria Basin in south-central Louisiana. Translated literally, Bayou Lafourche means "Bayou of the Fork" and is derived from the fact that the bayou was originally a west fork distributary of the Mississippi River. It is approximately 99 miles long, winding from Donaldsonville to the Gulf of Mexico. Bayou Lafourche Subsegment 020401 (Donaldsonville to the ICWW at Larose) is identified in the Modified Court Order 303(d) list as not meeting DO and nutrient criteria (EPA, 2000). This subsegment is approximately 69 miles long and has a drainage area estimated at 10 square miles. As directed by Section 303(d) of the Clean Water Act, TMDLs must be developed for waterbodies that are not meeting water quality standards, hence the preparation of this TMDL.

The suspected sources of oxygen depletion and nutrients in Bayou Lafourche are defined in the Louisiana 303(d) listing and are summarized below in Table 2.1. Most of the waterbodies in the Barataria Basin, including the referenced subsegment, do not meet the existing water quality criterion for DO (i.e., 5 milligrams per liter [mg/L]). Bayou Lafourche at Thibodaux, Louisiana, specifically has shown annual violations of the 5 mg/L DO standard until September 2001. Subsequent to 2001, until April 2004 (the last date for which data are available on the website of LDEQ), there have been no violations.

Table 2.1
Bayou Lafourche Listed Segment

Subsegment Number	Name	Segment Description	Size (miles)	Suspected Sources	Suspected Causes
020401	Bayou Lafourche	Donaldsonville to Intracoastal Waterway at Larose	68.0	• Minor municipal point sources • Package plants (small flows) • Collection system failure • Inflow and infiltration • Domestic wastewater lagoon • Land disposal • Septic tanks • Other, natural, and unknown sources • Flow regulations and/or modifications • Minor industrial point sources	Organic enrichment/low DO Nutrients

2.2 Land Use

Land use in Subsegment 020401 is predominantly residential and cropland. The primary crop grown in the area is sugar cane. Approximate percentages of each land use in the subsegment are shown in Table 2.2.

Table 2.2
Land Uses in Subsegment 020401

Land Use	Surface Area (acres)	Percent of Subsegment Area
Agricultural	3927.20	57.7%
Urban Residential	1408.89	20.7%
Water	932.46	13.7%
Forest	483.24	7.1%
Alluvial/Wetland Forest	54.45	0.8%
Total	6806.25	100.0%

Source: National Land Cover Data (mid-1990s).

2.3 Flow Characteristics

Approximately 2,000 years ago, Bayou Lafourche was the main distributary of the Mississippi River. About 800-1,000 years ago, the primary course of the Mississippi River changed to the current flow path past New Orleans. While it was active, the Bayou Lafourche distributary built a natural levee. After the river shifted to its modern course, the Bayou Lafourche distributary carried less water and the channel decreased in size. During high stages of the Mississippi River, the flow through the Bayou Lafourche channel still ranged from 6,000-11,000 cubic feet per second (cfs). By the late 1800s, development along Bayou Lafourche had become significant enough that steps were taken to dam the head of the channel, which later led to a permanent flood control levee at the Mississippi River (EPA, 1998).

Following the closure of the headwaters to Bayou Lafourche, the channel essentially became a stagnant ditch with the only water entering the bayou being direct rainfall, storm runoff, and wastewater discharges. Several attempts to pump or siphon water from the Mississippi River to the bayou were made early in the 20th century, but none were successful. Around 1950, the Bayou Lafourche Freshwater District was formed to siphon and/or pump Mississippi River water into the bayou in order to meet water supply needs and to combat saltwater intrusion. The rated capacity of the pump station at the head of the Mississippi River is 400 cfs, but the practical maximum is approximately 340 cfs.

In addition to direct rainfall on the bayou, wet weather runoff from the high ground that parallels the highways (Louisiana Highway 1 and Highway 308) on either side of the bayou reaches the bayou through more than 400 culverts and drainage ditches. Collectively, these culverts and ditches drain the land between the high points of the adjoining natural levees (that often crest a few hundred feet beyond the highways) and the bayou channel (EPA, 1998).

There are no significant hydraulic connections between Bayou Lafourche and other waterbodies from Donaldsonville to Raceland. Downstream of Raceland, Company Canal crosses Bayou Lafourche at Lockport and the ICWW crosses Bayou Lafourche at Larose. The ICWW typically flows in an eastward direction, bringing water from the Atchafalaya River into the Barataria Basin. At Thibodaux, there is a weir in Bayou Lafourche to maintain minimum water levels for the City of Thibodaux's water supply withdrawal. The bayou is somewhat tidally influenced downstream of this weir, but is not tidally influenced upstream of the weir (FTN Associates, 2003).

2.4 Designated Uses and Water Quality Standards

Designated uses for Bayou Lafourche Subsegment 020401 include primary and secondary contact recreation, propagation of fish and wildlife, and drinking water supply. The water quality criterion for DO for this subsegment is 5.0 mg/L. Numeric water quality criteria for nutrients are currently being developed but to date have not been implemented. However, qualitative standards for nutrients exist and require that the naturally occurring range of nitrogen to phosphorus ratios shall be maintained. Nutrient concentrations that produce aquatic growth to the extent that it creates a public nuisance or interferes with the designated water uses cannot be added to the receiving stream.

Louisiana water quality standards also include an antidegradation policy, which requires that state waters exhibiting high water quality be maintained at that high level of water quality. If maintenance of this level is not possible, water quality of a level that supports the designated uses of the waterbody should be maintained. Changing the designated uses of a waterbody to allow a lower level of water quality can only be achieved through a use attainability study.

2.5 Permitted Point Source Dischargers

A list of point source dischargers within Bayou Lafourche Subsegment 020401 was generated using a number of sources. This list is provided in Appendix A. In order to maintain consistency with other TMDLs within the subsegment, the original core of the inventory came from the point source discharger inventory list developed for the draft TMDL for Fecal Coliforms for Bayou Lafourche (FTN Associates, 2003).

Latitude/longitude data were added to the point source discharger inventory list. Latitude/longitude data were gathered from a number of sources, including data found in EPA's BASINS (Version 3.0, June 2001) software, DELORME's Street Atlas USA (Version 9.0, 2001), and the Louisiana Department of Environmental Quality (LDEQ) Electronic Document Management System (EDMS). EDMS was also used to obtain flow estimates, effluent discharge limitations, and other relevant information.

It should be noted that the permitted allowable flows were used for the TMDL model development. Table 2.3 shows the permit flows allowable under the different general sanitary permits held by the point source dischargers to Bayou Lafourche. Point source dischargers are assigned a specific permit number with the general permit number prefix (i.e., LAG5600215 is a point source permitted under permit LAG5600000).

Table 2.3
General Sanitary Permit Allowable Flows

General Permit Number	Allowable Flow (GPD)
LAG5600000	50,000
LAG5400000	25,000
LAG5300000	5,000

Discharges authorized under the general permit for carwashes (LAG750000) are limited to chemical oxygen demand (COD) of 300 mg/L. For use in the model, COD must be converted to 5-day biochemical oxygen demand (BOD_5) so that it can be considered in the modeling of DO. In general, the ratio of BOD_5 to COD will be less than 1.0, reflecting some fraction of the demand is not readily biodegradable. For carwash wastewaters, the ratio of BOD_5 to COD may range from 0.43 to 0.71 (Water Environment Federation, 1995). The more conservative 0.71 value was used in converting COD to a BOD_5 loading value for this study. The carwash general permit does not have an allowable flow limit, so based on limited available data on reported flows, a flow value of 750 gallons per day was assumed for each carwash point source.

For developing an input data file in the LA-QUAL model, the Louisiana TMDL Technical Procedures (LTP) manual (LDEQ, 2001) was used to convert the permitted point source loading values into values for ultimate BOD (BOD_u). Also, the LTP was used to develop input values for ammonia nitrogen (NH_3-N), and nitrite-nitrate nitrogen.

2.6 Nonpoint Sources

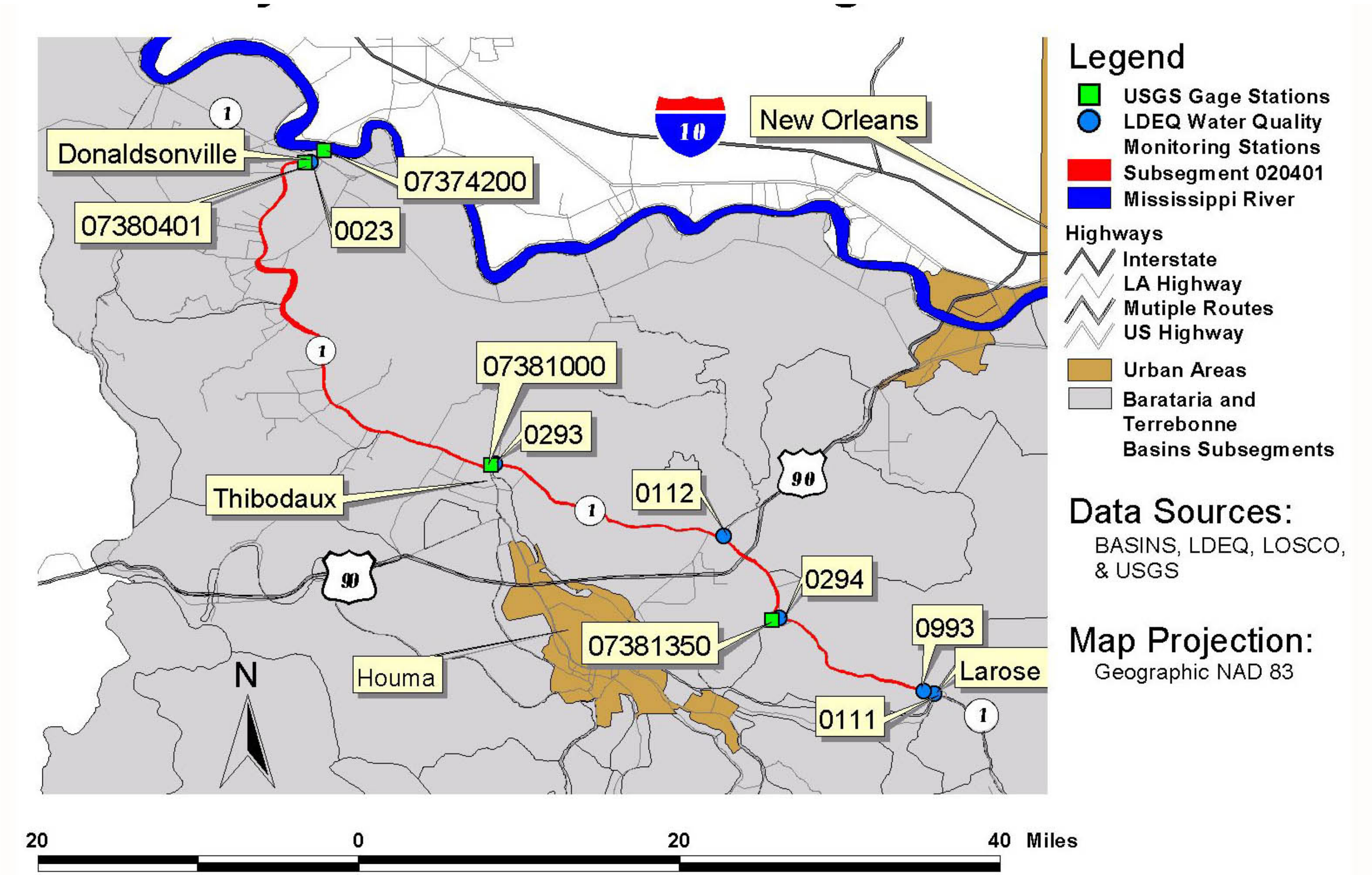
According to the 2000 Louisiana Nonpoint Pollutant Source Management Program Annual Report (LDEQ, 2000), suspected nonpoint sources listed for Bayou Lafourche Subsegment 020401 include septic tanks, natural sources, and unknown sources. The EPA Modified Court Order 303(d) list for Louisiana identified collection system failure, inflow and infiltration, land disposal, septic tanks, natural sources, and unknown sources as potential contributors to impairment.

Nonpoint source loadings associated with agricultural runoff primarily relate to soil losses. A recent study of runoff from sugar cane growing fields indicate that annual losses of nitrogen and phosphorus can range from 10 to 20 pounds of nitrogen per acre and 10 to 15 pounds of phosphorus per acre (Bengston, *et al.*, 1996). Nonpoint source loads considered in the model were represented as resuspended load from the bottom sediments and were modeled as nonpoint source biochemical oxygen demand loadings (kilograms per day [kg/d]). Nonpoint source loading rates (Data Type 19) were treated as calibration terms.

2.7 Previous Data and Studies

Listed below are previous water quality data and studies in or near the Bayou Lafourche subsegment. The locations of the LDEQ ambient monitoring stations are shown on Figure 2.1.

Figure 2.1 Monitoring Station Locations in Bayou Lafourche Subsegment 020401



1. Bi-monthly data collected by LDEQ for "Bayou Lafourche near Donaldsonville, Louisiana" (Station 0023) for field parameters (pH, temperature, DO, conductivity, secchi depth, and salinity) from 1972-1998; for nutrient parameters (nitrate-nitrite, total kjeldahl nitrogen [TKN], total phosphorus, and total organic carbon [TOC]) from 1978-1998; and for general parameters (alkalinity, hardness, turbidity, color, chlorides, sulfate, total suspended solids [TSS], and total dissolved solids [TDS]) from 1991-1998.

2. Monthly data collected by LDEQ for "Bayou Lafourche near Donaldsonville, Louisiana" (Station 0023) for general parameters (alkalinity, hardness, turbidity, color, chlorides, sulfate, TSS, and TDS) from 1972-1991.

3. Bi-monthly data collected by LDEQ for "Bayou Lafourche at Larose, Louisiana" (Station 0111) for field parameters from 1972-1990.

4. Monthly data collected by LDEQ for "Bayou Lafourche at Larose, Louisiana" (Station 0111) for field parameters in 2000; nutrient parameters from 1978-1990 and 2000; and for general parameters from 1972-1990 and 2000.

5. Bi-monthly data collected by LDEQ for "Bayou Lafourche at Raceland, Louisiana" (Station 0112) for field parameters from 1972-1998; nutrient parameters from 1991-1998; and for general parameters from 1991-1998.

6. Monthly data collected by LDEQ for "Bayou Lafourche at Raceland, Louisiana" (Station 0112) for nutrient parameters from 1978-1991; and for general parameters from 1972-1991.

7. Bi-monthly data collected by LDEQ for "Bayou Lafourche at Thibodaux, Louisiana" (Station 0293) for nutrient parameters from 1991-1998; and for general parameters from 1991-1998.

8. Monthly data collected by LDEQ for "Bayou Lafourche at Thibodaux, Louisiana" (Station 0293) for field parameters from 1991-2004; nutrient parameters from 1998-2001; and for general parameters from 1998-2001.

9. Bi-monthly data collected by LDEQ for "Bayou Lafourche at Lockport, Louisiana" (Station 0294) for nutrient parameters from 1991-1998; and for general parameters from 1991-1998.

10. Monthly data collected by LDEQ for "Bayou Lafourche at Lockport, Louisiana" (Station 0294) for general parameters from 1991-1998.

11. Real-time data (discharge rate, gauge height reading, and precipitation total for 1 to 31 day periods of time) provided by U.S. Geological Survey (USGS) for USGS Monitoring Station 07380401 — Bayou Lafourche SW of Donaldsonville, Louisiana.

12. Peak stream flow for the period of 1997-2001 and daily stream flow from 1996-2000 provided by USGS for USGS Monitoring Station 07380401 — Bayou Lafourche SW of Donaldsonville, Louisiana.

13. Real-time data provided by USGS for USGS Monitoring Station 07381000 — Bayou Lafourche at Thibodaux, Louisiana.

14. Peak stream flow for the period of 1966-2001, daily stream flow from 1984-2000, and water quality samples from 1963-1980 provided by USGS for USGS Monitoring Station 07381000 — Bayou Lafourche at Thibodaux, Louisiana.

15. Water Use and Quality of Fresh Surface-Water Resources in the Barataria-Terrebonne Basins, Louisiana, Report No. 98-632, 1998.

16. Reaeration Survey of Bayou Lafourche between Napoleonville and Labadieville, Louisiana, 2000, prepared by LDEQ.

17. Water intake rates provided by the Bayou Lafourche Fresh Water District from 1998-2003 for Assumption Parish Waterworks, City of Thibodaux Waterworks, Consolidated Waterworks of Terrebonne, Lafourche Parish Waterworks, and Peoples Water Service.

18. Average and peak water intake rates provided by the Bayou Lafourche Fresh Water District from 1998-2003 for the Valentine Paper Company, Caldwell Sugar Cooperative, Glenwood Cooperative, Lafourche Sugar Refinery, Lula Sugar Factory, and Raceland Raw Sugars.

3.0 CHARACTERIZATION OF EXISTING WATER QUALITY

3.1 Model Setup

LA-QUAL (Version 6.01) was selected to simulate the relationship between pollutant sources in Subsegment 020401 to the water quality of Bayou Lafourche. The LA-QUAL model was developed by the LDEQ for application to Louisiana stream conditions and has been applied to numerous subsegments throughout Louisiana for the development of TMDLs. LA-QUAL is a steady-state model that was adapted from QUAL-TX (Version 3.4.). Significant modifications to the QUAL-TX model that were made during the development of LA-QUAL include the addition of new aeration equations that more closely fit Louisiana conditions and the inclusion of default temperature correction constants that are listed in the LTP.

A windshield survey was performed on August 14, 2003, to evaluate potential point source dischargers and to locate feasible sampling locations on the subsegment. A summary of this windshield survey and photo log is provided in Appendix B. The LA-QUAL model was set up for calibration against water quality data that were obtained during the intensive survey that was conducted on September 23, 2003. Details concerning the intensive survey are provided in Appendix C.

Stations along Subsegment 0200401 are located according to River Kilometers (RK). Water quality data collected from Bayou Lafourche at Donaldsonville, Louisiana (RK 106.5), Thibodaux, Louisiana. (RK 54.0), and Larose, Louisiana (RK 0.0) were used to calibrate the model. Flow and gauge height data for the period of the intensive survey were obtained from

USGS real-time monitor stations that correspond with the locations where water quality data were collected at Donaldsonville and Thibodaux. Only gauge height data were available for the USGS monitor station at Larose.

Hydrogeometric data (width and depth for the flows observed during the calibration period) were obtained from a HEC-RAS hydraulic model that was developed by Mashriqui and Kemp (1998) to simulate various scenarios for diverting fresh water from the Mississippi River to Bayou Lafourche. The HEC-RAS model incorporated 1993 field survey data for 192 channel cross-sections along the 108-kilometer (km) subsegment. A 1997 re-survey of the sections showed good agreement and that no significant changes had occurred in section geometry (Mashriqui and Kemp, 1998). The HEC-RAS model simulated headwater flows ranging from 4.2 cubic meters per second (cms) (150 cfs) to 9.6 cms (340 cfs). Four hydrologically distinct segments were identified by Mashriqui and Kemp along the subsegment based primarily on hydrogeometry. The Bayou Lafourche LA-QUAL model was set up with four segments matching those established by Mashriqui and Kemp for all projection scenarios. Assumed hydrogeometric data for Scenario 4b (maximum flow of 1,000 cfs) were obtained from Mashriqui and Kemp based on projected increased surface area profiles anticipated to be developed under a higher future flow diversion. Also, this maximum flow scenario assumed removal of the weir at Thibodaux would be associated with future flow diversion construction efforts.

3.2 Calibration Period and Calibration Targets

The intensive field survey period (September 23, 2003) was selected as the calibration period for the Bayou Lafourche LA-QUAL model. Sufficient USGS real-time hydraulic monitoring data were available for the period during which the intensive survey occurred (Appendix D). The intensive field survey period was also determined to approximate critical flow and temperature conditions for streams in Louisiana, as described in the LTP (LDEQ, 2001). Monitoring data were also collected at locations (coincident with routine monitoring stations) representing the headwaters, lower boundary, and mid-segment and, thus, were considered sufficient for calibration.

Calibration of the LA-QUAL model near critical conditions was desirable for use in developing TMDLs for critical conditions. The time of travel for flow between Donaldsonville and Larose for the flow rates measured during the calibration period was calculated to be 9 days. The time of travel between Donaldsonville and Thibodaux was estimated to be 4.5 days. Headwater flow for the calibration period was therefore determined based on the average daily flow measured at the Donaldsonville USGS gauge station between September 15 and 23, 2003. A 9-day flow average of 5.44 cms was calculated for the Donalsonville station. To determine the presence of any inflows between Donaldsonville and Thibodaux that were not otherwise accounted for by point source loadings, the 9-day flow average for the USGS gauge at Thibodaux was calculated for September 19 to 27, 2003. The 9-day flow at Thibodaux was 5.80 cms. The additional flow measured at Thibodaux was attributed to storm water flows to the bayou during the 9-day time of travel. Precipitation at the Donaldsonville USGS monitor station measured approximately 2.29 cm during the 9-day period. This precipitation amount was verified against records made available through the Louisiana Agriclimate Information System (LAIS) agricultural climate monitor station at Paincourtville, Louisiana, located near the USGS Donaldsonville Station. (Appendix D). The approximate inflow due to storm water for the calibration period was then calculated by balancing flows into and out of Reaches 1 and 2 (between Donaldsonville and Thibodaux) using the following equation:

$$Q_{\text{Storm Water}} = Q_{\text{Thibodaux}} - Q_{\text{Donaldsonville}} + \Sigma Q_{\text{Point Sources in Reaches 1 and 2}} - \Sigma Q_{\text{Withdrawals in Reaches 1 and 2}}$$

A storm water flow of 1.489 cms was determined using this equation. Because numerous ditches and canals drain to Bayou Lafourche between Donaldsonville and Thibodaux, the additional flow to Reaches 1 and 2 was modeled as distributed inflows within Reaches 1 and 2. Inflows to each reach were based on the percent of the subsegment drainage area located upstream of the downstream reach boundary. Inflows were modeled under Data Types 16, 17, and 18 and are described in Sections 3.17 and 3.18.

Calibration targets for the LA-QUAL model included ultimate carbonaceous biochemical oxygen demand (CBOD), organic nitrogen, ammonia nitrogen (NH_3-N), nitrite plus nitrate nitrogen ($N0_2$+$N0_3$-N), total phosphorus, chlorophyll-*a*, and DO. Ultimate CBOD ($CBOD_u$) was approximated using 20-day CBOD ($CBOD_{20}$) concentrations. Quality control objectives for the model calibration were set at plus or minus 50 percent of the measured data as described in the modeling quality assurance project plan (QAPP).

A copy of the calibration input file is provided in Appendix E.

3.3 Model Options (Data Type 2)

Model options were selected based on which constituents needed to be modeled in order to achieve calibration. The simulation of dissolved oxygen, effective biological oxygen demand, the nitrogen series, phosphorus, and chlorophyll-*a* were selected in the calibration input file.

3.4 Program Constants (Data Type 3)

The LA-QUAL model allows for the specification of program constants that override default values. Hydraulic calculation method 2 (utilizing modified Leopold equations as described in the LTP) was selected in order to simulate widths and depths for the simulation of flow though each computational element. The maximum iteration limit was set to 2000 in order to allow for convergence of simulation calculations.

A two-step inhibition equation (Equation 1) as opposed to the default three-step inhibition equation (Equation 2) was specified for nitrification rates. For DO greater or equal to 7.8 mg/L, the nitrification is 1.0. For DO less than 7.8 mg/L, the nitrification is calculated as:

$$(1.2 \text{ x DO})/(1.56 + \text{DO})$$

The specification of Equation 1 is consistent with the approach used in QUAL-2e and approaches used by others for TMDL models of Louisiana streams. The effective BOD resulting from algae was specified to be the ratio of 0.20 mg/L BOD per micrograms per liter (µg/L) chlorophyll-*a*. Default values were used for all other program constants.

3.5 Temperature Correction of Kinetics (Data Type 4)

LA-QUAL default values are consistent with the temperature corrections to rate coefficients that are provided in the LTP except for ammonia-nitrogen decay and the reaeration rate. A temperature correction value of 1.07 was specified for ammonia-nitrogen decay and 1.024 was specified for the reaeration rate. Both correction values correspond with what is provided in the LTP.

3.6 Temperature Data (Data Type *5)*

For the purposes of this TMDL for DO and nutrients, temperature was not simulated.

3.7 Algae Constants (Data Type 6)

LA-QUAL default values for oxygen production due to algal growth, oxygen uptake due to respiration, algal nitrogen content, phosphorus content, nitrogen half saturation constant, phosphorus half saturation constant, and light saturation constant were selected.

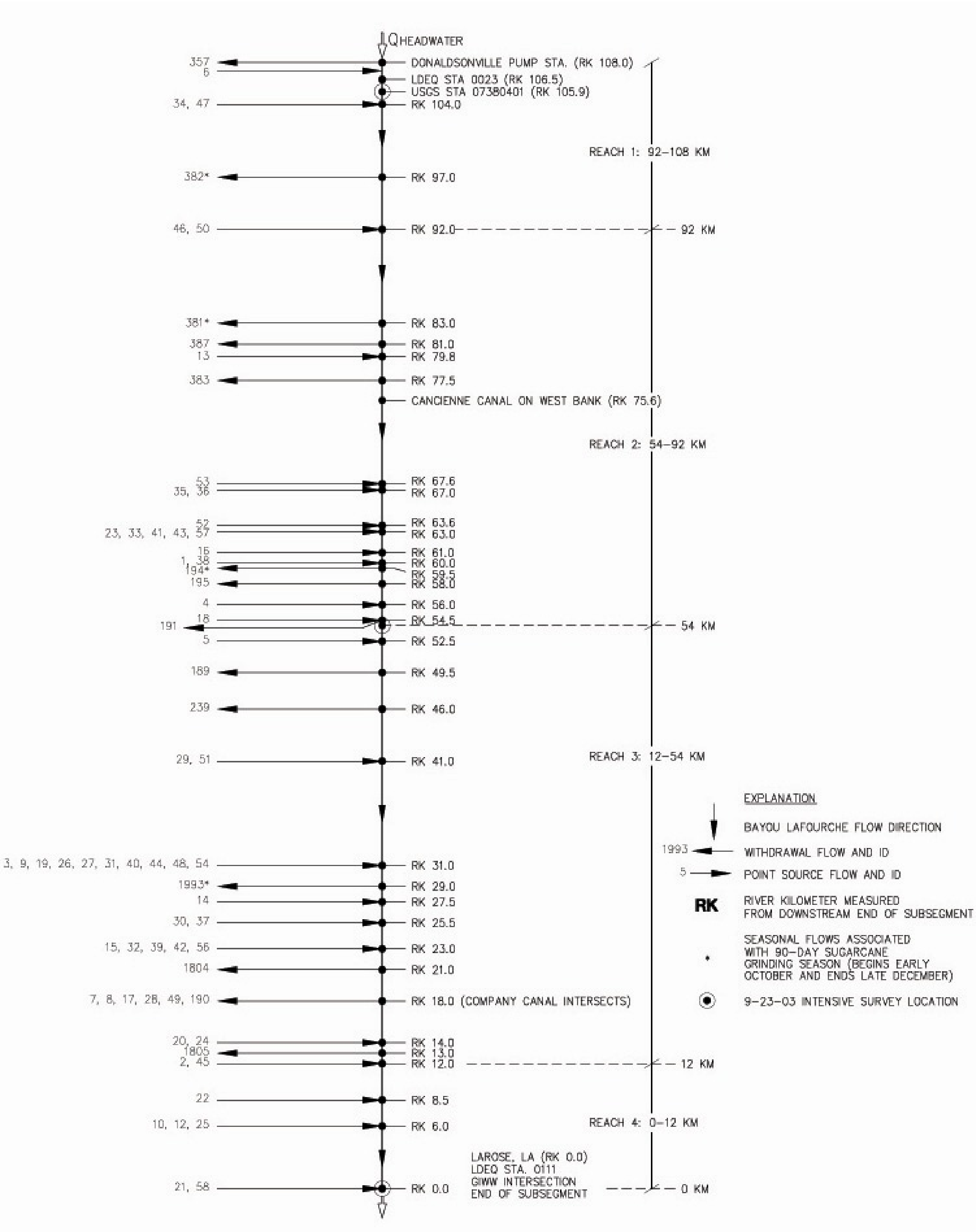
3.8 Macrophyte Constants (Data Type 7)

Macrophytic growth along the bottom of Bayou Lafourche is typically minimal due to limited light penetration in the water column. Historically, floating *Hydrilla* has been observed and harvested along Bayou Lafourche, especially between Thibodaux and Larose. The only appreciable bands of *Hydrilla* observed during the calibration period were narrow and predominantly located along the banks of Bayou Lafourche between Lockport and Larose and immediately upstream of the bridge at Lockport. Macrophytes were not sampled during the intensive survey. Due to limited data quantifying the overall density and effects of *Hydrilla* on nutrient and DO concentrations in Bayou Lafourche and the relatively sparse population of *Hydrilla* observed during the calibration period, macrophyte simulations were not performed as part of this TMDL for DO and nutrients.

3.9 Reach Identification Data (Data Type 8)

As previously discussed in Section 3.1, four segments or reaches were specified for the Bayou Lafourche model. Reach 1 begins near Donaldsonville and extends approximately 16 km downstream, from RK 108 to RK 92. Reach 2 extends 38 km from the downstream boundary of Reach 1 to Thibodaux, from RK 92 to RK 54. Reach 3 extends 42 km from Thibodaux to Lockport, from RK 54 to RK 12. Finally, Reach 4 is approximately 12 km in length and connects Lockport and Larose, from RK 12 to RK 0. A schematic of the LA-QUAL model segmentation is provided on Figure 3.1. A computational element length of 0.1 km was specified for each reach.

Figure 3.1 Schematic of the LA-QUAL Model Segmentation



3.10 Advective Hydraulic Coefficients (Data Type 9)

Surface widths and average depths for each of the four specified reaches were obtained from hydraulic simulations for existing conditions in Bayou Lafourche generated by Mashriqui and Kemp (1998). These simulations were performed using the Hydrologic Engineering Center - River Analysis System (HEC-RAS) software. Widths and depths were derived by averaging the widths and depths from the upstream, middle, and downstream portions of each reach that corresponded with flows measured during the calibration period. All widths and depths were specified as constants (width constant “c” and depth constant “f”). All width and depth coefficients and exponents were set to zero. Slopes for each reach were estimated from the HEC-RAS flow profiles. A Manning’s “n” of 0.021 was used. This Manning’s “n” is consistent with values previously used in hydraulic models of Bayou Lafourche that were generated by the U.S. Army Corps of Engineers (1994) and by Mashriqui and Kemp (1998).

3.11 Dispersive Hydraulic Coefficients (Data Type 10)

Tidal dispersion (E; sq. m/s) in the La-QUAL model is calculated as $E = aD^{b}Q^{c}V_{T}^{d}$ where D is the stream depth, Q is flow, and V_T is tidal velocity. Dispersion due to tidal fluctuation in the subsegment was not measured as part of this study. Analytical data collected during the field survey showed a net loss of total nitrogen in the subsegment between Thibodaux (1.30 mg/L at RK 54.0) and Larose (1.00 mg/L at RK 0.0). In order to appropriately account for the contribution of tidal dispersion to total nitrogen loss, a constant tidal dispersion factor (“a” in the above referenced equation) of 800 sq m/s was furnished to the model for the two most downstream reaches. This dispersion factor is consistent with available measured tidal dispersion factors for coastal riverine estuaries in the United States. The dispersion coefficient used for the upstream two reaches of the model were internally computed by the La-QUAL model.

3.12 Initial Conditions (Data Type 11)

Initial temperature and DO, ammonia nitrogen, nitrite plus nitrate nitrogen, phosphorus, and chlorophyll-*a* were specified for each reach based on data collected during the intensive survey. Because salinity and macrophytes were not simulated, initial concentrations for these parameters were specified as zero.

3.13 Reaeration, SOD, and BOD Coefficients (Data Types 12)

An explicit reaeration coefficient of 0.6/day was specified for Reaches 1 through 4. This reaeration coefficient was derived from a reaeration study that was conducted by the LDEQ on Bayou Lafourche between March 14 and 15, 2000 (LDEQ, 2000). The reaeration study was conducted between Napoleonville and Labadieville, Louisiana, and utilized propane and dye injections. Average flow during the reaeration study was 5.27 cms.

The ultimate carbonaceous biochemical oxygen demand ($CBOD_u$) and aerobic decay rate (referred to as BOD#1) were used as calibration terms for DO and effective BOD respectively. Nonpoint source loadings, including SOD, were modeled under Data Type 19 (Nonpoint Source Loadings; see Section 3.19). A BOD#1 settling rate and settled BOD#1 conversion to SOD were each set to zero initially. No anaerobic BOD#1 decay rate or other BOD decay rates were specified.

3.14 Nitrogen and Phosphorus Coefficients (Data Type 13)

Organic nitrogen decay rates, ammonia nitrogen oxidation rates, and denitrification rates were used as calibration parameters in order to reproduce the organic nitrogen, ammonia nitrogen, and nitrite-nitrate nitrogen concentrations measured during the intensive survey. The organic nitrogen settling rate, background benthos source rate for ammonia nitrogen, and background benthos source rate for phosphorus were initially set at zero.

3.15 Algae and Macrophyte Coefficients (Data Type 14)

No algae or macrophyte samples were collected during the intensive survey. Chlorophyll-*a* analyses were performed on samples collected from the water column. A secchi disc depth with no algae present was set at 1.0 meter. This depth was thought to be reasonable because the bayou generally exhibits either turbid conditions downstream of the Donaldsonville pump station and downstream of the Thibodaux weir or an otherwise dark organic color elsewhere in the bayou. Chlorophyll-*a* was simulated as a surrogate constituent for phytoplankton in the water column. An algae to chlorophyll-*a* ratio of 0.015 mg algae per microgram (µg) Chlorophyll-*a* was specified. A settled algae conversion to SOD was estimated at 0.5 based on the portion of carbonaceous algal biomass that would consume oxygen upon decay. Initially, the algae maximum growth rate, algae respiration rate, and algae settling rate were used as calibration terms during iterative calibration runs and adjusted as necessary to achieve calibration with the Chlorophyll-*a* concentrations measured during the calibration period. An algal settling rate of 0.2 meter (m) per day was estimated based on the range of settling rates presented in EPA's Rates, Constants, and Kinetics Formulations in Surface Water Quality Modeling (2nd Edition) (1985) and Chapra (1997) for various phytoplankton. An algal maximum growth rate of 2.0 per day and an algal respiration rate of 0.05 per day were specified based on rates found for total phytoplankton in EPA (1985).

3.16 Coliform and Nonconservative Coefficients (Data Type 15)

Neither of these constituents affect dissolved oxygen in the La-QUAL model; therefore, no coefficients were specified under Data Type 15.

3.17 Incremental Data for Flow, Temperature, Salinity, and Conservatives (Data Type 16)

Incremental flows were specified to account for loadings to Bayou Lafourche that resulted from precipitation and runoff during the estimated time of travel between Donaldsonville and Larose. As previously discussed in Section 3.2, the magnitude of storm water that entered the subsegment between Donaldsonville and Thibodaux was approximated by balancing flows into and out of Reaches 1 and 2. Because temperature, salinity, and conservatives were not simulated, concentrations of these constituents were specified as zero.

3.18 Incremental Data for Water Quality Parameters (Data Types 17 and 18)

No evidence of storm water flows in ditches and canals entering the subsegment and resulting from the precipitation that was measured at Donaldsonville was observed during the intensive survey. Cancienne Canal (located on the west side of the bayou at RK 32.4) typically drains away from the bayou and to Lake Verret. Because the most upstream drainage area of Cancienne Canal is characteristic of the Bayou Lafourche drainage area, and in the absence of actual storm water characterization data, water quality samples and *in situ* measurements taken in Cancienne Canal at the Louisiana Highway 1 crossing were used to represent storm water DO, $CBOD_u$, organic nitrogen, ammonia nitrogen, and nitrite plus nitrate nitrogen concentrations for incremental flows entering Bayou Lafourche between Donaldsonville and Thibodaux. Coliform and nonconservative constituent concentrations were given values of zero. Constituent concentrations for Cancienne Canal are shown in Appendix C (Intensive Survey Report).

3.19 Nonpoint Source Loads (Data Type 19)

As discussed in Section 2.6, nonpoint source loads, including SOD, to the subsegment were modeled as BOD loading rates to each reach. Nonpoint source loading rates were approximated as calibration terms for each reach and explicitly specified under Data Type 19.

3.20 Headwater Flow Rate (Data Type 20)

A single pump station at Donaldsonville, Louisiana (Walter Lemann, Sr. Pumping Station), serves as the only source of headwater flow to the subsegment. The pump station is located at RK 108.0. The Donaldsonville USGS monitor station (07380401) is located at RK 106.5 and records gauge height, flow, and precipitation in real time. Because of the proximity of the USGS station to the Donaldsonville pumping station, headwater flow rates to the subsegment were determined using data from this USGS station and flow data for withdrawals and point sources located between the Donaldsonville pump station and the USGS gauge station. USGS flow data corresponding to the calibration period are provided in Appendix D. The headwater flow rate was determined using the following flow balance equation:

$$Q_{\text{Headwater}} = Q_{\text{Donaldsonville USGS Sta.}} + \Sigma\, Q_{\text{Withdrawals}} - \Sigma\, Q_{\text{Point Sources}}$$

The resulting headwater flow to the subsegment was 5.49 cms. Flow calculations are provided in Appendix F.

3.21 Headwater Data for Water Quality Parameters (Data Types 21 and 22)

Because of the proximity of the most upstream end of the subsegment (RK 108.0) to the intensive survey sample point at Donaldsonville (RK 105.9), water quality data from the intensive survey were used to specify constituent concentrations in the headwater for DO, $CBOD_u$, organic nitrogen, ammonia nitrogen, total phosphorus, and chlorophyll-*a*. A listing of the water quality data for the Donaldsonville sample location is provided in Appendix C.

3.22 Junction Data (Data Type 23)

Subsegment 020401 was modeled as a linear stream segment having a single headwater. There were no stream junctions in the model and no data on junctions were furnished.

3.23 Waste Load Data for Flow, Temperature, Salinity, and Conservatives (Data Type 24)

Sixty-four Louisiana Pollutant Discharge Elimination System (LPDES) permits were identified in Subsegment 020401. A full listing of point sources is provided in Appendix A. Reported actual flows and permitted constituent concentrations were used to model point sources for the calibration period. Because temperature, salinity, and conservatives were not simulated, no data were inputted for these parameters.

3.24 Waste Load Data for Water Quality Parameters (Data Types 25 and 26)

Data characterizing permitted point source loads to the subsegment were obtained from reviews of EPA's Permit Compliance System (PCS) and LDEQ databases as described in Section 2.5. Where 5-day BOD concentrations were reported for point sources, these concentrations were converted to ultimate CBOD using a conversion of 2.3 mg/L $CBOD_u$ per mg/L BOD_5. This conversion factor agrees with the conversion factor recommended in the LTP for all treatment levels. For point sources, such as carwashes, that reported COD, the reported COD concentration was converted to $CBOD_u$ using a conversion of 0.71 mg/L $CBOD_u$ per mg/L COD. No effluent DO or nitrogen concentrations were reported for point source loads. An effluent DO concentration of 2.0 mg/L (as specified in the LTP) was assigned to all point sources in the subsegment assumed to be equipped with secondary treatment. Ammonia concentrations were set at 15.0 mg/L based on guidance provided in the LTP. Organic nitrogen concentrations for point sources were assumed to equal 50 percent of the ammonia nitrogen concentrations for secondary treatment. Nitrite plus nitrate nitrogen were assumed to equal 10 mg/L for secondary treatment.

3.25 Lower Boundary Conditions (Data Type 27)

The intensive survey sample location at Larose corresponded with RK 0.0 for Subsegment 020401. Therefore, *in situ* and analytical water quality data for this intensive survey sample location were used to represent lower boundary conditions during the calibration period. A listing of data for the Larose location is provided in the Intensive Survey Report (Appendix C). Data were specified for only those parameters that were being simulated by the model. All other parameters were set to zero.

3.26 Dam Data (Data Type 28)

Flow over the Thibodaux weir at approximately RK 54.0 was observed during the calibration period. The Thibodaux weir was modeled as a sharp-crested weir dam with a static head loss of 0.6 m. The static head was estimated from the flow profile produced by Mashriqui and Kemp (1998) for the calibration flow.

3.27 Calibration Methodology

The LA-QUAL model for Bayou Lafourche was calibrated against data collected in the intensive survey in the following sequence. The model was executed and modeled flows were checked against flows measured at the Donaldsonville and Thibodaux USGS gauge stations. Next, effective CBOD (BOD#1) was calibrated by adjusting CBOD decay. Then, organic nitrogen was calibrated by adjusting organic nitrogen decay rates followed by the organic nitrogen settling rates. Ammonia nitrogen was calibrated by adjusting ammonia nitrogen oxidation rates. Settling rates for CBOD and organic nitrogen and benthic source rates for ammonia and phosphorus were not used if modeled concentrations were within the data quality objectives (DQO) (+/-50 percent) of the measured concentrations. Chlorophyll-*a* was calibrated by adjusting the algae settling rate, algae maximum growth rate, and algae respiration rate for each reach until the modeled Chlorophyll-*a* concentration was within 50 percent of the measured concentration. Finally, DO was calibrated by adjusting the nonpoint source loading rate for each model reach.

3.28 Model Results for Calibration

A copy of the calibration output file is provided in Appendix G. Graphs showing the modeled and measured calibration parameters are provide in Appendix H. The calibrated model was determined to adequately reproduce the measured constituent concentrations in the Bayou and was considered acceptable based on meeting the DQOs established in the modeling QAPP.

4.0 WATER QUALITY MODEL PROJECTION

Guidance provided by the EPA states that “TMDLs shall take into account critical conditions for stream flow, loading, and water quality parameters (40 CFR 130.7 (c)(1)). The LTP defines “critical conditions” in terms of streamflow rate and temperature (LDEQ, 2001). Critical conditions are further specified for the summer and winter seasons as follows:

- Summer Season (May through October) Critical Conditions:

  The 7Q10 flow rate or 0.0028 cms (0.1 cfs), whichever is greater. Background temperature of 30° Celsius (C) or the 90th percentile of daily water temperatures when appropriate data are available. Based on monitoring station data, the 90th percentile daily water temperature for summer season in Bayou Lafourche is 30.27°C.

- Winter Season (November through April) Critical Conditions:

  The 7Q10 flow or 0.0283 cms (or 1 cfs), whichever is greater. Background temperature of 20°C or the 90th percentile of daily water temperatures, when appropriate data are available. Based on monitoring station data, the 90th percentile daily water temperature for winter season in Bayou Lafourche is 20.80°C.

4.1 Model Projection Input Data

The overall 7Q10 for Bayou Lafourche of 1.4 cms (49.1 cfs) is presented by Lee in "Low-flow on Streams in Louisiana" (2000) and is based on 10 years of historic flow data for USGS Station 7381000 at Thibodaux, Louisiana. The overall 7Q10 was used as the summer season critical flow for summer model projections. Thirteen years of daily flow data beginning in 1994 were obtained from the USGS website (www.usgs.gov) for the Thibodaux station in order to determine the winter season 7Q10. A statistical probability analysis of the daily flow data resulted in a winter season 7Q10 of 1.5 cms (52.5 cfs). The statistical probability analysis is presented in Appendix D. The headwater flow to Bayou Lafourche from the Mississippi River was then calculated for summer and winter seasons by performing a flow balance that considered the flow at Thibodaux and flow contributions from point sources and withdrawal flows to facilities located between the upstream boundary of the subsegment in Donaldsonville and the Thibodaux USGS station. Headwater flows were calculated using the following equation:

$$Q_{\text{Headwater}} = Q_{\text{Thibodaux}} + \Sigma\, Q_{\text{Withdrawals}} - \Sigma\, Q_{\text{Point Sources}}$$

where $Q_{\text{Headwater}}$ = 7Q10 flow to Reach 1(cms);
$Q_{\text{Thibodaux}}$ = 7Q10 flow for Thibodaux USGS station (cms);
$Q_{\text{Withdrawals}}$ = withdrawal flows to facilities (cms); and
$Q_{\text{Point Sources}}$ = point source flows from permitted discharges.

Data are available for five LDEQ statewide ambient water quality monitoring stations located along Bayou Lafourche on a monthly and bi-monthly basis depending on the station. These stations are Donaldsonville (0023), Thibodaux (0293), Raceland (0112), Lockport (0294), and Larose (0111).

As previously discussed in Section 3.23 (Waste Load Data for Flow, Temperature, Salinity, and Conservatives [Data Type 24]), reported actual flows and permitted constituent concentrations for point sources were used in model calibration. Model projections assumed that point sources were discharged at permitted flow rates and concentrations. Permitted flow rates for each point source are listed in Appendix A. Identification numbers and associated flows assigned to each point source for the purpose of the TMDL are provided in Appendix E. Only one point source (Point Source 18) discharges on a seasonal basis (September and October). Therefore, this discharge was only included in summer model projections.

Withdrawal rates used in the calibration model were applied to the seasonal model projections. Because seasonal withdrawal for sugar cane grinding facilities occurs between early October and late December, overlapping the summer and winter seasons, critical flow conditions for both summer and winter season model projections included these withdrawal rates.

The LTP specifies that headwater DO concentrations for model projections should be set at up to 90 percent of the DO saturation at the 90th percentile seasonal temperature. This procedure was not followed for the projection runs made in this study. Headwater DO concentrations for flow from the Mississippi River were set to 5.0 mg/L. Critical temperatures were set at 20.8°C for the winter season and 30.7°C for the summer season based on calculations of 90th percentile seasonal temperatures (Appendix I). Concentrations of all other constituents in the headwater specification remained unchanged from the calibration model. The DO concentration for the lower boundary condition was similarly set to 5.0 mg/L. All other constituent concentrations for the lower boundary remained unchanged from the calibration model.

All rates, hydraulic constants, and coefficients were left unchanged from those used in the calibration model. Hydraulic widths and depths in Bayou Lafourche at low flow conditions are controlled by the weir at Thibodaux (RK 54.0) and by tidal elevations at Larose (RK 0.0); therefore, hydraulic widths and depths were assumed to approximate those provided in the calibration model and were left unchanged in the season model projections.

Input and respective output files for each projection scenario are presented in Appendices J through M as outlined below.

- Scenario 1 – Current loading scenario, that includes all point sources, nonpoint sources, and natural background contributions under critical streamflow and temperature conditions for summer and winter seasons (see Appendix J for input and output files);

- Scenario 2 – Modified loading scenario, as necessary to meet the 5.0 mg/L DO standard, through the increase or reduction of all existing loading (point sources, nonpoint sources, and natural background contributions) until the DO standard is met (see Appendix K);

- Scenario 3 – Modified nonpoint source loading scenario, as necessary to meet the 5.0 mg/L DO standard, through the increase or reduction of existing nonpoint source loading and natural background contributions until the DO standard is met (see Scenario 2);

- Scenario 4 – Modified flow scenario, utilizing a minimum diversion from the Mississippi River (Scenario 4a) to achieve the 5.0 mg/L DO standard in the extant model developed under the first three scenarios, and a projected diversion of 1,000 cfs from the Mississippi River for the subsegment without the fixed weir at Thibodaux and increased cross-sectional areas due to anticipated dredging (Scenario 4b) (see Appendix L); and

- Scenario 5 – Loading evaluation scenario, utilizing the extant model developed under the first three scenarios that demonstrates the relative impact of point and nonpoint loading through the elimination of all point source loading (Scenario 5a) and elimination of all nonpoint source loading (Scenario 5b) (see Appendix M).

4.3 Model Projection Results

As outlined in Section 4.2, output files for projection Scenarios 1 though 5 are presented in Appendices J through M (The results for Scenario 3 are the same as those for Scenario 2). Initial summer and winter projections under Scenario 1 (Current loading scenario) with no modifications to the source loads showed that modeled DO concentrations in the subsegment were all above the 5.0 mg/L standard (minimum projected DO concentration of 6.80 mg/L). Figures 4.1 and 4.2 indicate the concentration of DO will increase downstream of the Mississippi River diversion, reaching a peak near Thibodaux, and will decrease downstream of Thibodaux. This result is caused by the assumed concentrations of 5 mg/L for the Mississippi River diversion and at Larose. Had these concentrations been set at 90 percent of saturation, the simulated DO profile would have been more linear.

Figure 4.1 Scenario 1 DO Projection for Summer Critical Conditions

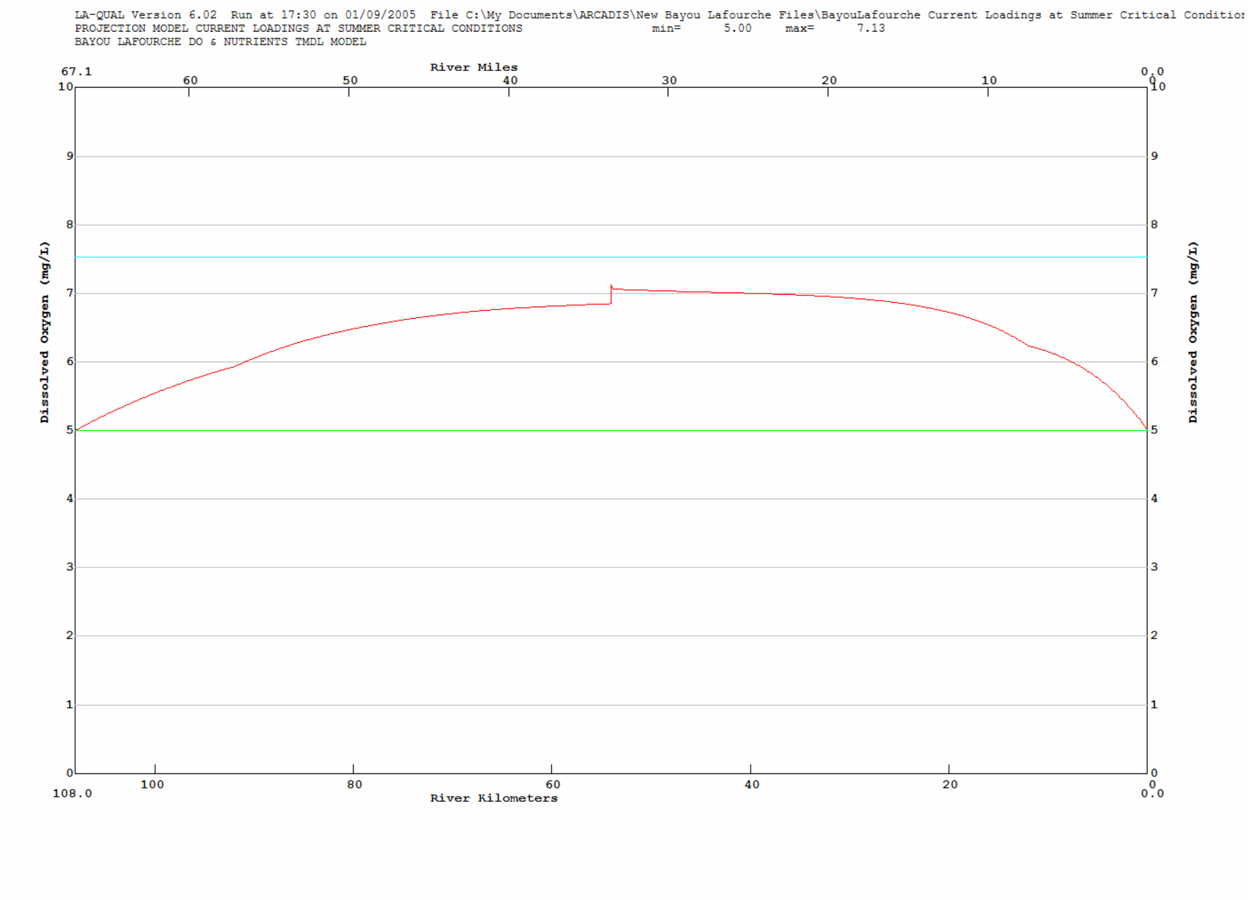
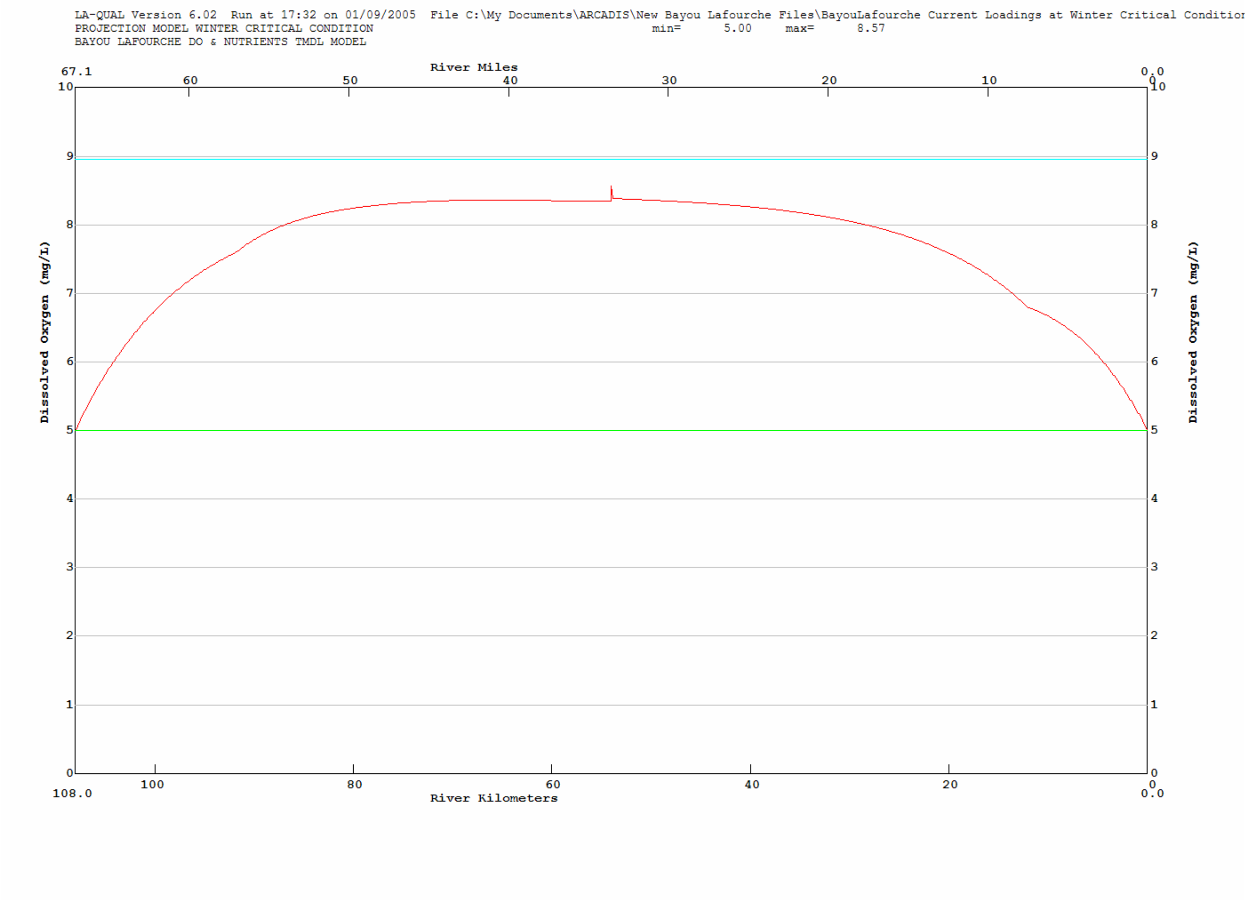


Figure 4.2 Scenario 1 DO Projection for Winter Critical Conditions



Under Scenario 2 (Figures 4.3 and 4.4), the nonpoint source loading rate (see Section 3.19) for the subsegment was iteratively increased to determine assimilative capacity beyond current loadings such that the DO standard is met. Nonpoint source loadings were increased in each reach beginning at the upstream end and proceeding to the downstream end of the subsegment.

Figure 4.3 Scenario 2 DO Projection for Summer Critical Conditions

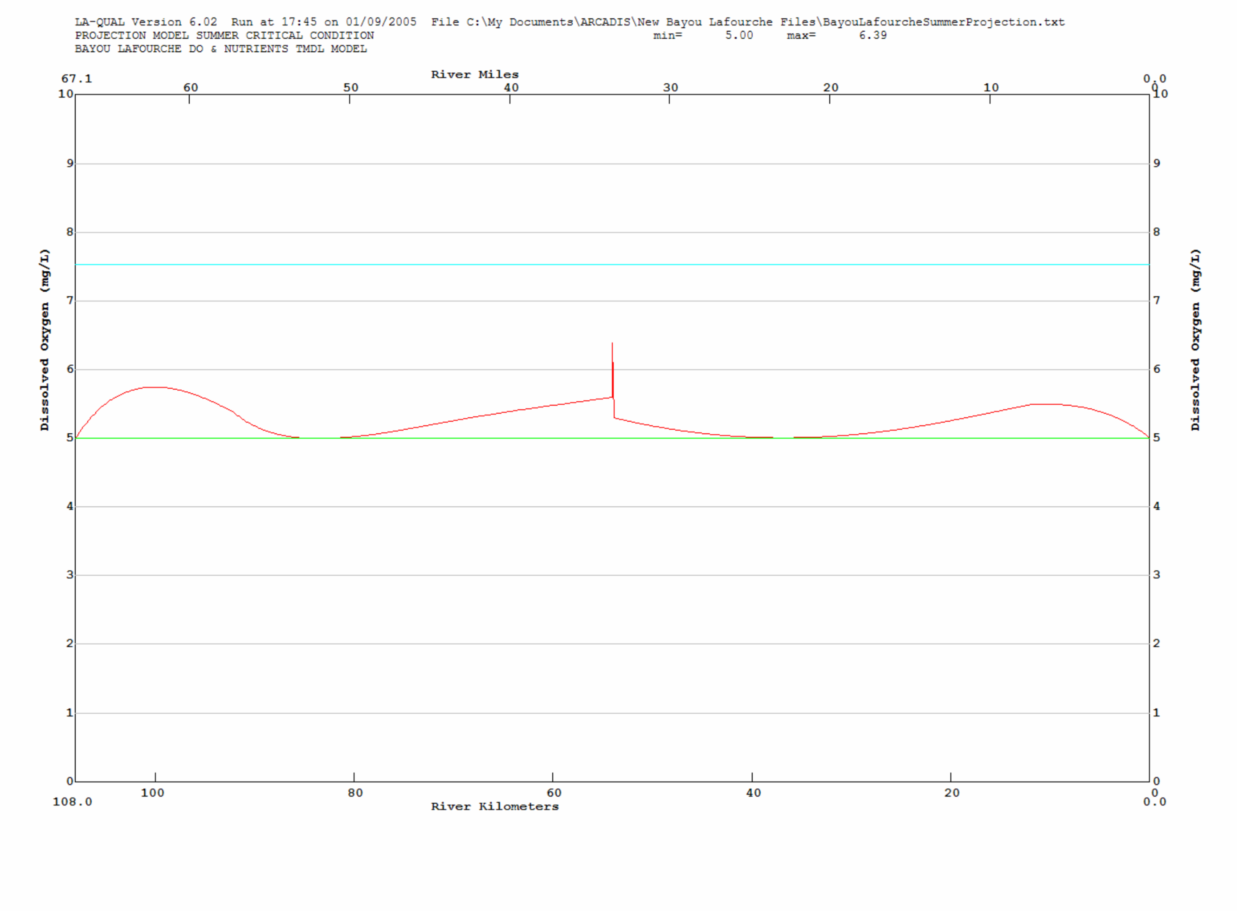
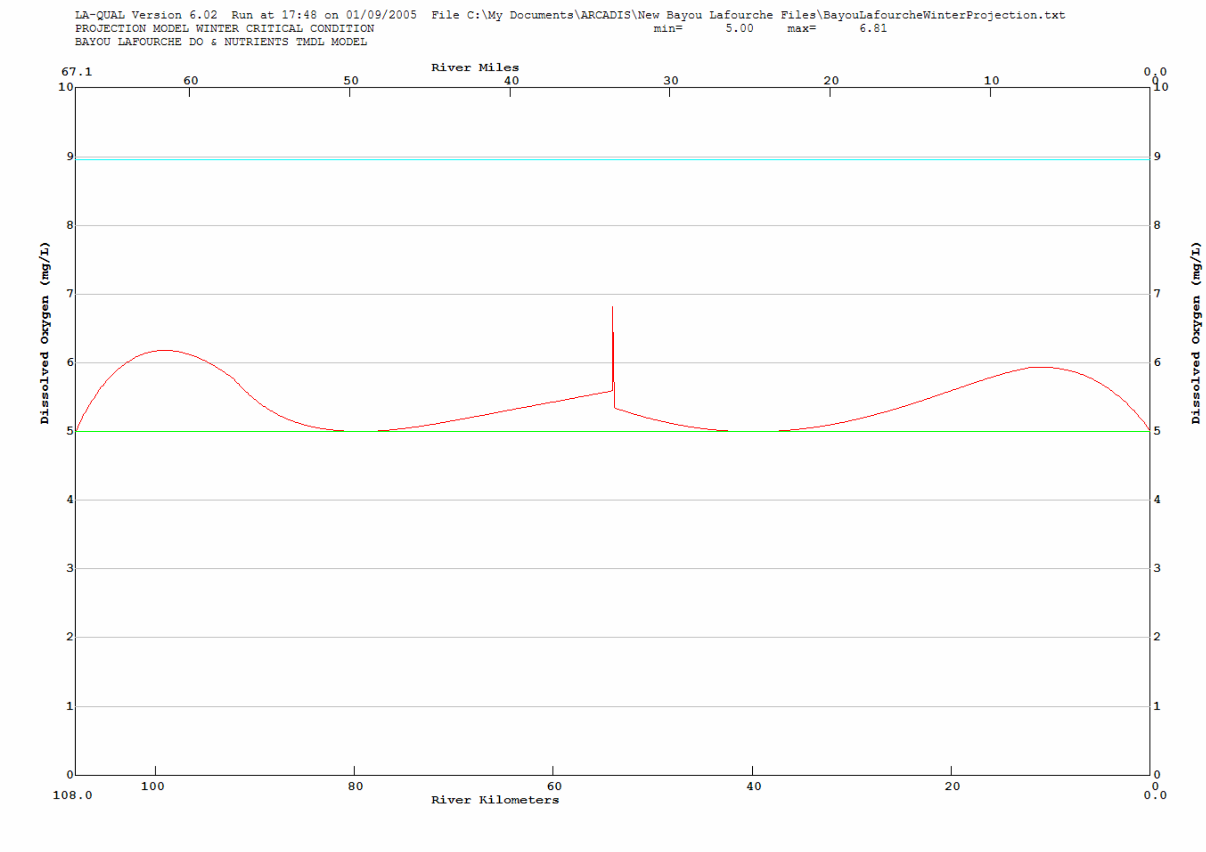


Figure 4.4 Scenario 2 DO Projection for Winter Critical Conditions



Because the 5.0 mg/L DO standard is met throughout the subsegment for critical conditions, the load reductions of Scenario 3 (iterative reductions of point source and nonpoint source loadings, respectively) were not required to be implemented to achieve the DO standard.

Under Scenario 4a (Figures 4.5 and 4.6), the projection shows that the 5.0 mg/L DO standard can be maintained at a minimum flow of 2.1 cfs under summer critical temperature conditions. The 5.0 mg/L DO standard was projected to be maintained even at zero flow under winter critical temperature conditions. Interpretation of both simulations should be tempered because the fixed measured reaeration rate was used. This reaeration rate may not be uniform in practice under field conditions.

Figure 4.5 Scenario 4a DO Projection for Summer Critical Conditions at Minimum Flow to Maintain DO Standard

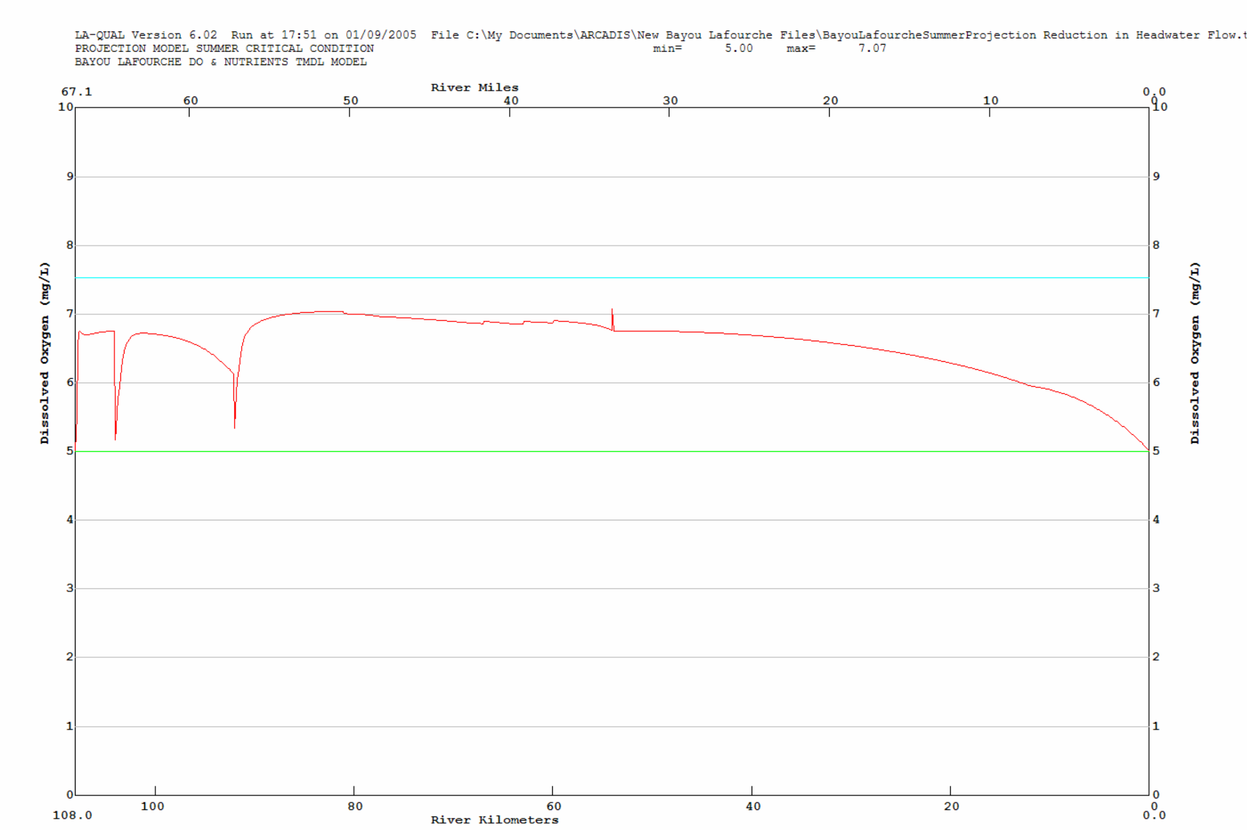
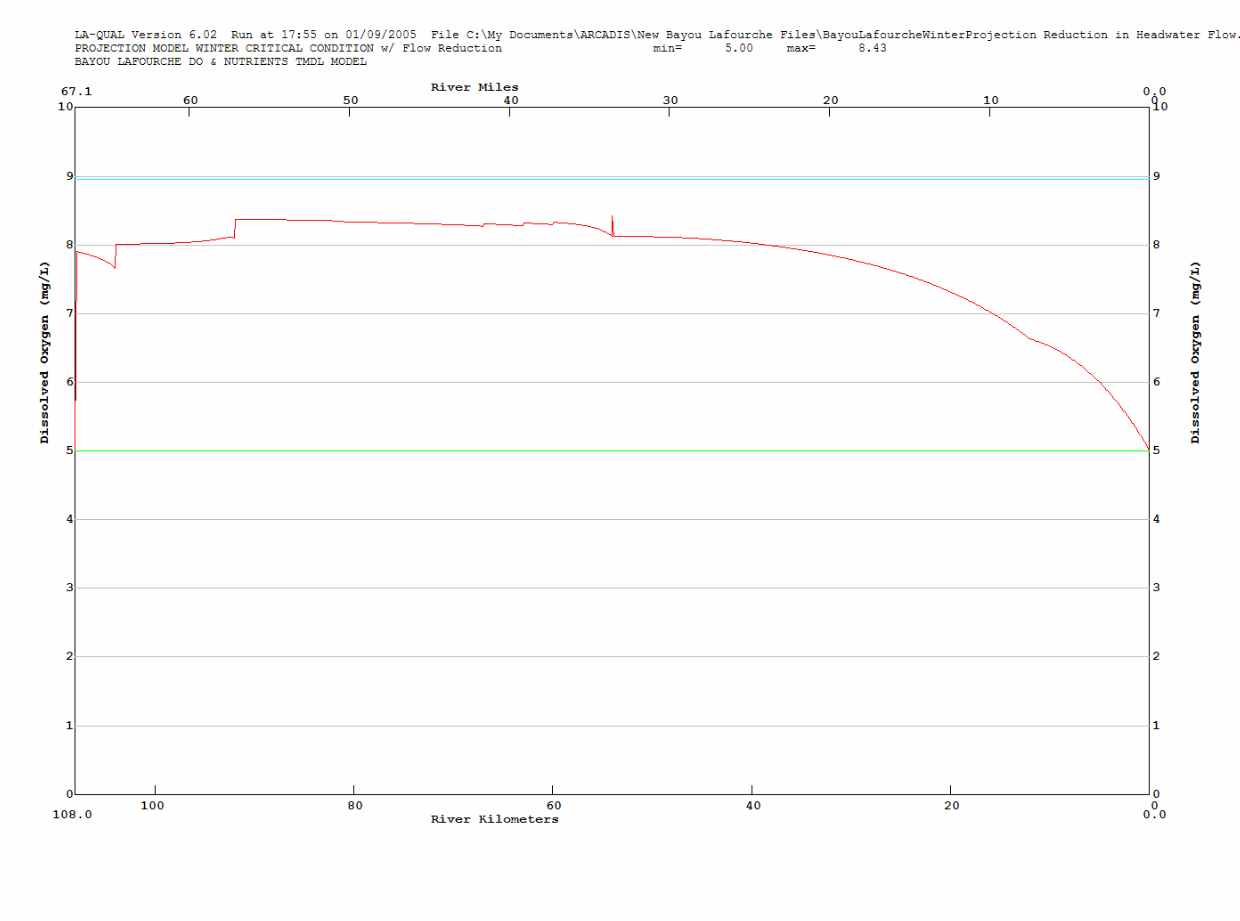


Figure 4.6 Scenario 4a DO Projection for Winter Critical Conditions at Minimum Flow to Maintain DO Standard



Projections for Scenario 4b (Figures 4.7 and 4.8) demonstrate that by increasing the Mississippi River diversion flow to 1,000 cfs and removing the weir at Thibodaux, the 5.0 mg/L DO standard is maintained under both summer and winter conditions. Figures 4.7 and 4.8 show the projected DO concentrations when oxygen-demanding loading rates are increased beyond current loading rates such that the 5.0 mg/L standard is maintained throughout the subsegment.

Figure 4.7 Scenario 4b DO Projection for Summer Critical Conditions at 1000 cfs and Weir Removed to Maintain DO Standard

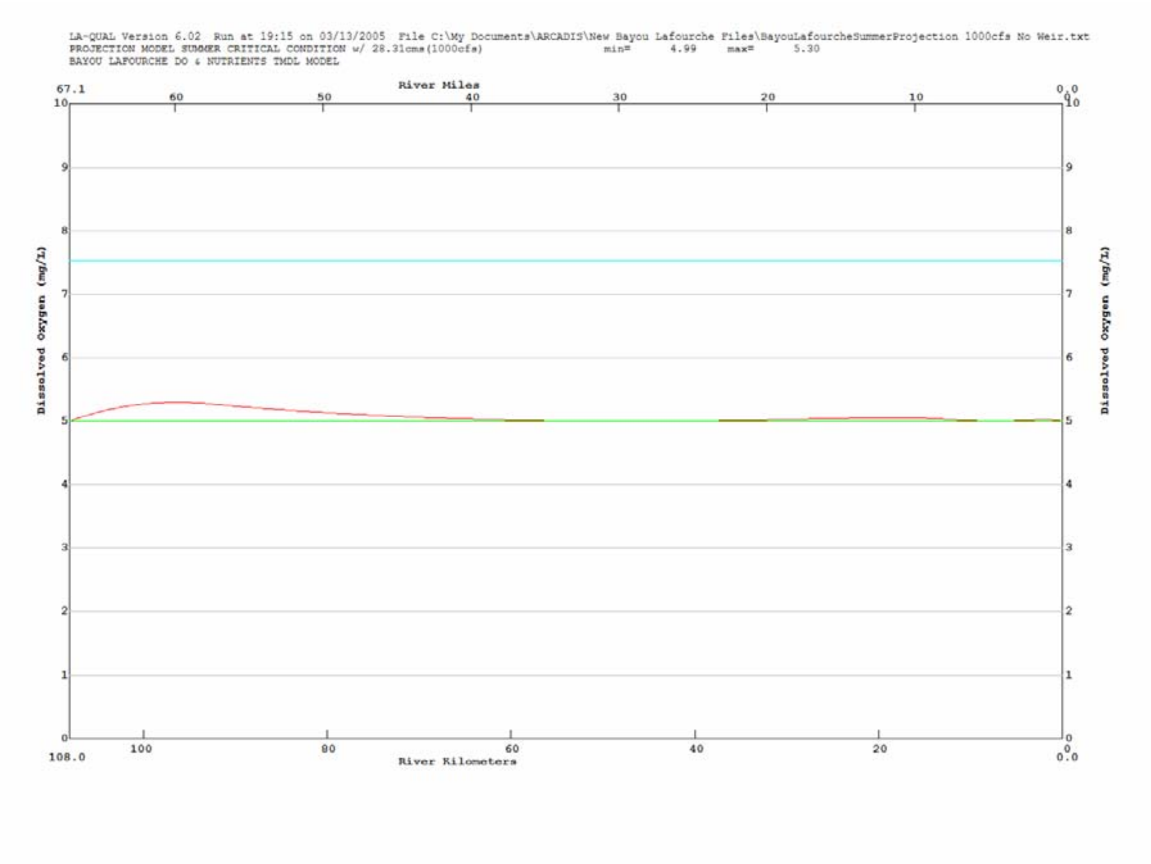
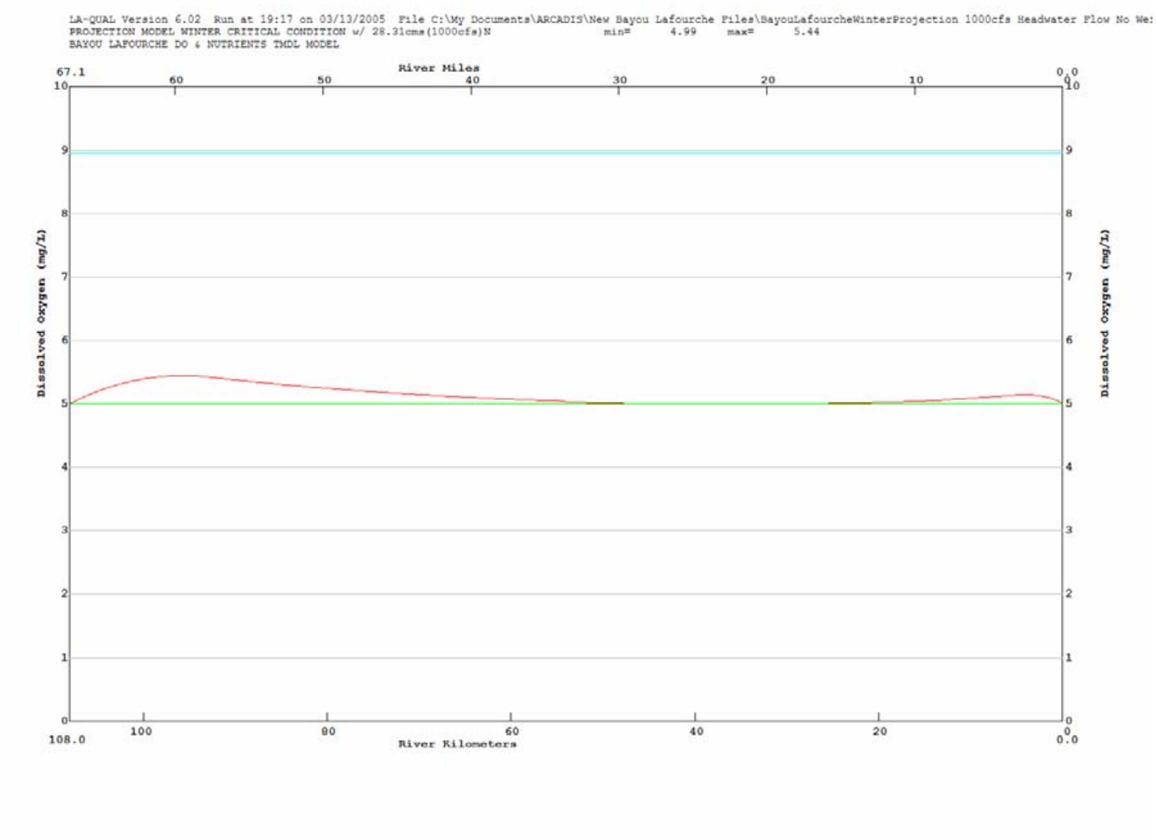


Figure 4.8 Scenario 4b DO Projection for Winter Critical Conditions at 1000 cfs and Weir Removed to Maintain DO Standard



Projections for Scenario 5 (Loading Evaluation Scenario) demonstrate the relative contribution of current point source oxygen-demanding substances (Scenario 5a [Figures 4.9 and 4.10]) and of current nonpoint source loadings (Scenario 5b [Figures 4.11 and 4.12]) under summer and winter critical conditions. Projected DO concentrations in the subsegment all were above the 5.0 mg/L standard.

Figure 4.9 Scenario 5a DO Projection for Summer Critical Conditions

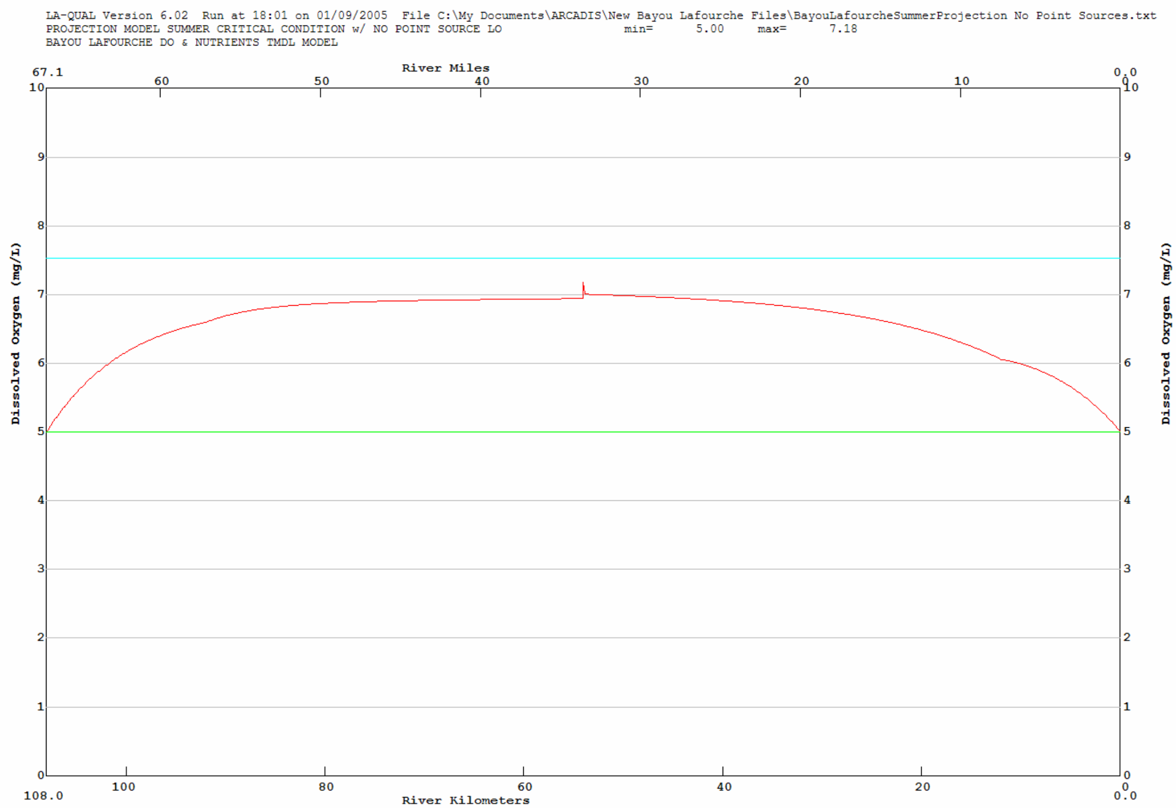


Figure 4.10 Scenario 5a DO Projection for Winter Critical Conditions

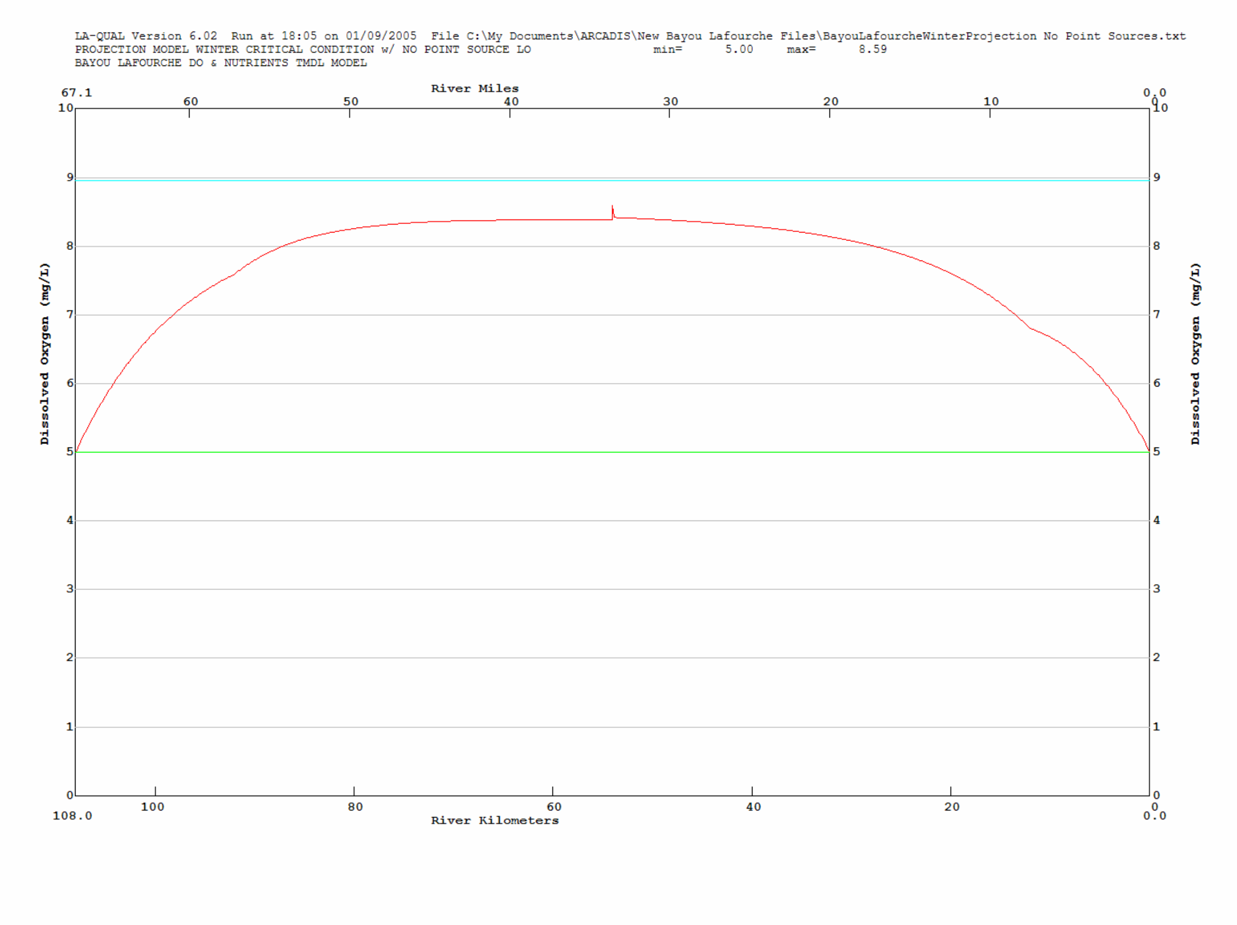


Figure 4.11 Scenario 5b DO Projection for Summer Critical Conditions

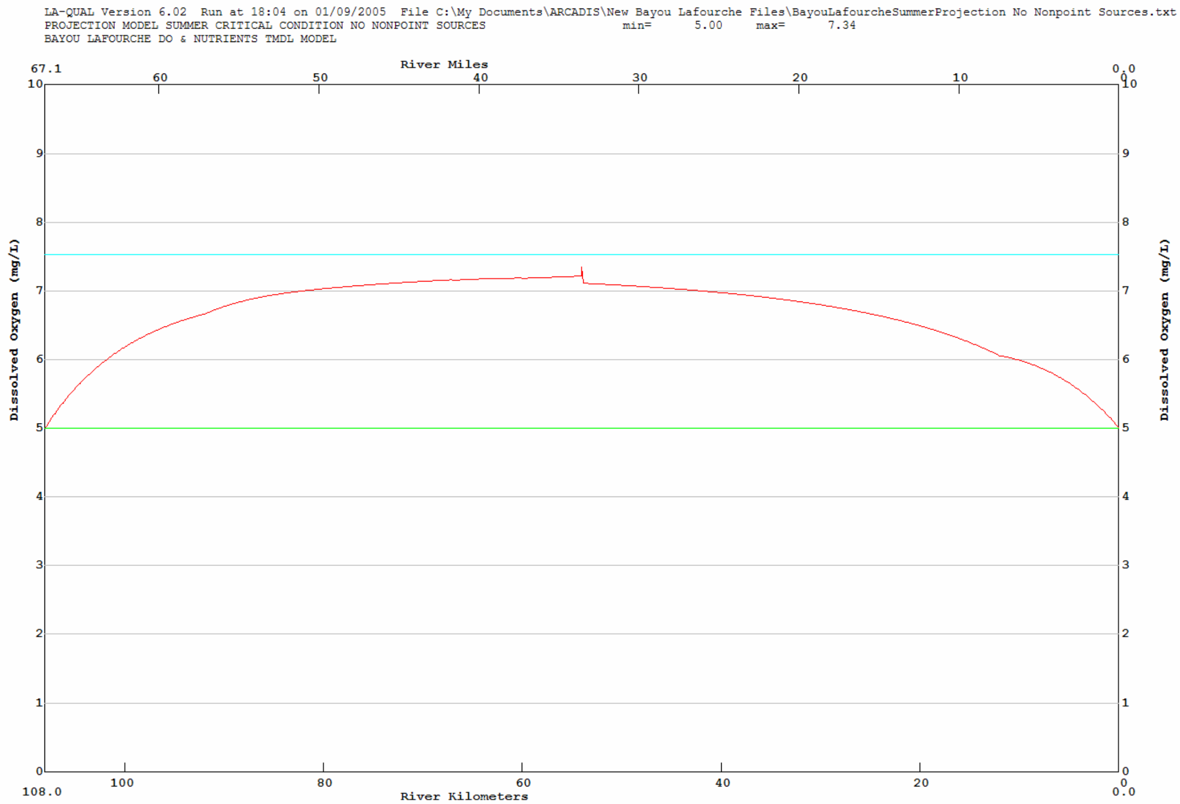
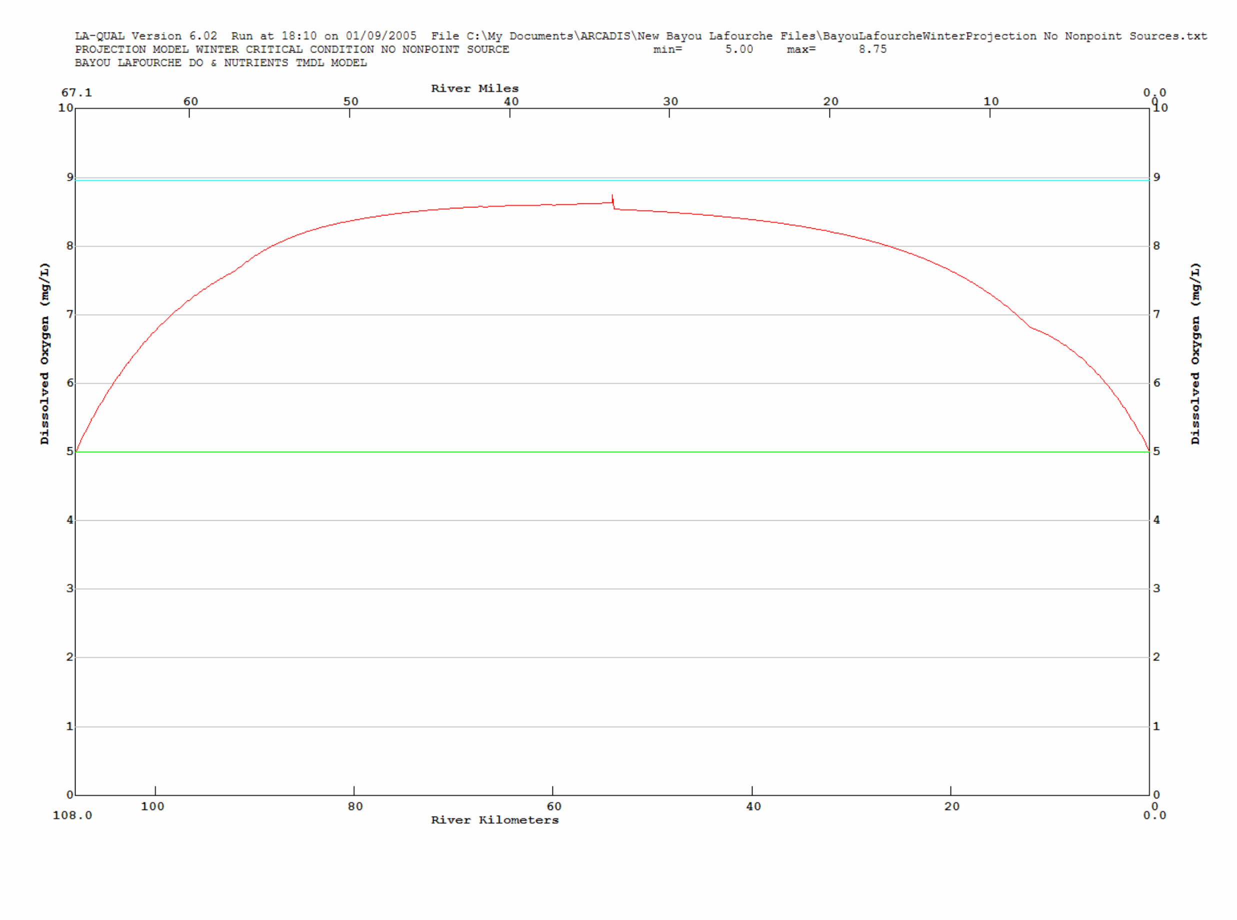


Figure 4.12 Scenario 5b DO Projection for Winter Critical Conditions



Under both summer and winter critical conditions, the effect of eliminating point source discharges to instream DO concentrations is minimal when compared to the results from Scenario 1. This observation underscores the small contribution of oxygen-demanding substances from existing point sources in the subsegment. The impact of eliminating nonpoint sources on projected instream DO concentrations was also minimal. Slight increases in instream DO concentrations (<0.3 mg/L) were apparent for that portion of the subsegment upstream of the Thibodaux weir (RK 54.0).

5.0 SENSITIVITY ANALYSES

Sensitivity analyses were performed for model parameters using tools provided in LA-QUAL. The calibrated model was modified to allow variations of plus and minus 30 percent for all parameters except temperature. Temperature was varied by plus and minus 2°C. The results for the sensitivity analyses were compared against the base model minimum DO concentration. Results of the sensitivity analyses are presented in Table 5.1. When tidal flushing downstream of the Thibodeaux weir was approximated using dispersion, the DO and all other constituent concentrations at the downstream boundary of the model were required to be specified. Constituent concentrations for upstream boundary conditions are always required to be specified in a one-dimensional model such as LaQUAL. For the calibration simulations, the upper boundary DO (7.49 mg/L) and the lower boundary DO (5.83 mg/L) reflected what was measured in the field. For the projection runs, the DO concentrations at the upstream and downstream ends of the model were set to be concentrations that represented the water quality standard in segments upstream and downstream of Subsegment 020401. As a result, the upper and lower boundary DO concentrations had a greater impact on the minimum DO in the subsegment than the other variables and parameters tested in the sensitivity analysis.

Table 5.1 Summary of Results of Sensitivity Analyses

Parameter	%Param Chg	Min D.O.	%D.O. Chg	%Param Chg	Min D.O.	%D.O. Chg
Headwater Flow	-30.	5.84	0.0	30.	5.84	0.0
Headwater DO	-30.	5.25	-10.0	30.	5.84	0.0
Headwater BOD	-30.	5.84	0.0	30.	5.84	0.0
Headwater Chlorophyll a	-30.	5.84	0.0	30.	5.84	0.0
Headwater Ammonia	-30.	5.84	0.0	30.	5.84	0.0
Headwater Nitrate	-30.	5.84	0.0	30.	5.84	0.0
Headwater Phosphorus	-30.	5.84	0.0	30.	5.84	0.0
Headwater Organic Nitrogen	-30.	5.84	0.0	30.	5.84	0.0
Stream Depth	-30.	5.84	0.0	30.	5.84	0.0
Stream Reaeration	-30.	5.84	0.0	30.	5.84	0.0
BOD Decay Rate	-30.	5.84	0.0	30.	5.84	0.0
Algae/Chlorophyll Ratio	-30.	5.84	0.0	30.	5.84	0.0
Ammonia Decay Rate	-30.	5.84	0.0	30.	5.84	0.0
Organic Nitrogen	-30.	5.84	0.0	30.	5.84	0.0
Algae Growth Rate	-30.	5.84	0.0	30.	5.84	0.0
Algae Respiration	-30.	5.84	0.0	30.	5.84	0.0
Algae Settling Rate	-30.	5.84	0.0	30.	5.84	0.0
Incremental Inflow	-30.	5.84	0.0	30.	5.84	0.0
Incremental DO	-30.	5.84	0.0	30.	5.84	0.0
Incremental BOD	-30.	5.84	0.0	30.	5.84	0.0
Incremental Chlorophyll a	-30.	5.84	0.0	30.	5.84	0.0
Incremental Ammonia	-30.	5.84	0.0	30.	5.84	0.0
Incremental Nitrate	-30.	5.84	0.0	30.	5.84	0.0
Incremental Phosphorus	-30.	5.84	0.0	30.	5.84	0.0
Incremental Organic Nitrogen	-30.	5.84	0.0	30.	5.84	0.0
Wasteload Flow	-30.	5.84	0.0	30.	5.84	0.0
Wasteload DO	-30.	5.84	0.0	30.	5.84	0.0
Wasteload BOD	-30.	5.84	0.0	30.	5.84	0.0
Wasteload Ammonia Nitrogen	-30.	5.84	0.0	30.	5.84	0.0
Wasteload Nitate Nitrogen	-30.	5.84	0.0	30.	5.84	0.0
Wasteload Phosphorus	-30.	5.84	0.0	30.	5.84	0.0
Wasteload Organic Nitrogen	-30.	5.84	0.0	30.	5.84	0.0
Initial Temperature	-2.	5.84	0.0	2.	5.84	0.0
Stream Dispersion	-30.	5.84	0.0	30.	5.84	0.0
Lower Boundary Temperature	-2.	5.84	0.0	2.	5.84	0.0
Lower Boundary DO	-30.	4.10	-29.8	30.	7.32	25.3
Lower Boundary BOD	-30.	5.84	0.0	30.	5.84	0.0
Lower Boundary Chlorophyll a	-30.	5.84	0.0	30.	5.84	0.0
Lower Boundary Ammonia	-30.	5.84	0.0	30.	5.84	0.0

6.0 TMDL CALCULATIONS

6.1 DO TMDL

The TMDLs for DO for summer and winter critical conditions were calculated based on the results of scenario model projections presented in Section 4.0. The TMDL calculations were performed using spreadsheets developed in Microsoft Excel. Copies of the TMDL calculations for Scenarios 2 through 4 are provided in Appendices N through P.

6.1.1 Margin of Safety (MOS)

A conservative approach in calculating TMDLs for a stream or reach provides some assurance that the model accounts for uncertainty, seasonal variations, growth, and error. Performing projection analyses at the 7Q10 flow and the 90th percentile of empirical temperature data, or temperatures recommended in the LTP, assumes that both conditions occur simultaneously. In addition, an explicit MOS is commonly applied to TMDL calculations. The following methodology was applied to determine an MOS for Bayou Lafourche:

- An explicit MOS was applied to each subsegment equal to 10 percent of the TMDL for the subsegment; and

- Where no reserved capacity was available in the modeled subsegments, the MOS was subtracted from the nonpoint source loading at critical conditions. The resulting load was designated as the nonpoint source LA.

The 10 percent MOS was determined to be sufficient for application to Subsegment 020401 for the following reasons:

- Seasonal projection models assume that critical temperature and flow conditions occur simultaneously in the modeled subsegment; and

- Point source loadings used in the model assumed that maximum permitted flow and maximum permitted concentrations occurred during critical temperature and flow conditions.

6.1.2 Calculated TMDL, WLAs, and LAs

The 5.0 mg/L DO standard is maintained under existing loading conditions for both summer and winter critical seasons for Scenario 1. Therefore, no reductions in either point source or nonpoint source loadings are necessary to maintain the DO standard under critical conditions under Scenario 1.

To calculate the TMDL under Scenario 2, loads were increased to determine the assimilative capacity in the subsegment beyond current loadings. The WLAs, LAs, and MOS for Scenario 2 are listed in Table 6.1 in both English and metric units. No determination of anthropogenic versus natural nonpoint source demands could be made based on the available field and analytical data. Oxygen demand due to anthropogenic and natural nonpoint sources is combined into one term, the benthal or SOD rate. A 10 percent MOS was assigned to allow for model uncertainty, seasonal variations, future growth, and error.

Table 6.1
TMDL (sum of $CBOD_u$ and $NBOD_u$) Under Scenario 2 for Subsegment 020401 (Bayou Lafourche from Donaldsonville to the ICWW in Larose)

Load Description	Summer (May-Oct)	Winter (Nov-April)
Current Point Source Loadings at Critical Conditions (kg/d of UOD)	533	396
Current Nonpoint Source Loadings at Critical Conditions (kg/d of UOD)	3,053	3,053
Maximum Point Source Loadings at Critical Conditions (kg/d of UOD)	533	396
Maximum Nonpoint Source Loadings at Critical Conditions (kg/d of UOD)	20,009	31,550
Point Source WLA (kg/d of UOD)	533	396
Nonpoint Source LA (kg/d of UOD)	17,955	28,355
MOS (kg/d of UOD)	2,054	3,195
Assimilative Capacity (kg/d of UOD)	20,542	31,945
Reserve Capacity (kg/d of UOD)	14,902	25,302
TMDL (kg/d of UOD)	20,542	31,945
TMDL (lbs/d of UOD)	45,287	70,426
% Reduction in Nonpoint Source Loadings Required:	0	0
% Reduction in Point Source Loadings Required:	0	0

kg/d = kilogram per day
lbs/d = pounds per day
UOD = sum of $CBOD_u$ and $NBOD_u$

The resulting allowable point source allocations associated with Scenario 2 are summarized in Table 6.2.

Table 6.2
TMDL Point Source Allocations Under Scenario 2 for Subsegment 020401
(Bayou Lafourche from Donaldsonville to the ICWW in Larose)

Permit Number	Company	FAC Type	TMDL Allocated Point Source Loading (lbs/day of BOD_5)	TMDL Allocated Point Source Loading (g/day of BOD_5)
LA0063303	LAFOURCHE PARISH HOUSING AUTHORITY	SEWERAGE PLANT	9.38	4255.90
LA0084069	BOLLINGER SHIPYARDS LOCKPORT, LLC	SHIPYARD	17.04	7728.72
LA0095788	GAUBERT OIL CO INC	SERVICE STATION	0.98	442.61
LA0107174	PELTS & SKINS EXPORT LTD	ALLIGATOR FARM	127.90(1)	58016.46(1)
LA0107361	Scrubb's INC (CARWASH)	CARWASH	0.19	85.12
LAG530005	AMERICAN BIOCHEMICAL CORPORATION	SEWERAGE PLANT	1.88	851.18
LAG530043	AUCOIN'S SEWER UTILITY SERVICE	4,000 GPO OX POND	1.88	851.18
LAG530068	BECK'S	SEWERAGE PLANT	1.88	851.18
LAG530100	BURGER KING CORP	RESTAURANT	1.88	851.18
LAG530127	CHINA GARDENS	EXTENDED AERATION (4510 GPD)	1.88	851.18
LAG530185	ECONOMY INN	MOTEL	1.88	851.18
LAG530268	JB LEVERT LAND CO INC	220 GPD HOOT AEROBIC TREATMENT	1.88	851.18
LAG530272	JIM'S FROSTOPS INC	RESTAURANT	1.88	851.18
LAG530290	LA DEPT OF TRANS & DEVELOPMENT	BRIDGE	1.88	851.18
LAG530307	LA DEPT OF TRANS & DEVELOPMENT	BRIDGE	1.88	851.18
LAG530318	LAFOURCHE PAR COUNCIL	BRIDGE	1.88	851.18
LAG530322	LAFOURCHE PAR SCH BD	PUBLIC SCH	1.88	851.18
LAG530342	LOCKPORT VOLUNTEER FIRE DEPT	SEWERAGE PLANT	1.88	851.18
LAG530343	LOCKPORT VOLUNTEER FIRE DEPT	SEWERAGE PLANT	1.88	851.18
LAG530407	PAPPYS FRIED CHICKEN	RESTAURANT STP	1.88	851.18
LAG530439	RACELAND DAIRY KOOL	SEWERAGE PLANT	1.88	851.18
LAG530461	RICHARD LEDETS TRAILER PARK	SEWERAGE PLANT	1.88	851.18
LAG530559	LITTLE FRENCH MARKET, INC	RESTAURANT STP	1.88	851.18
LAG530672	BAYOU FOOD STORES INCICANAL REFINING C	SERVICE STATION	1.88	851.18
LAG530679	ROUSES ENTERPRISES INC	GROCERY STORE/STP	1.88	851.18
LAG530874	JOEYS SEAFOOD & LOUNGE	RESTAURANT/LOUNGE	1.88	851.18

Permit Number	Company	FAC Type	TMDL Allocated Point Source Loading (lbs/day of BOD_5)	TMDL Allocated Point Source Loading (g/day of BOD_5)
LAG530887	SITA INC	MOTEL	1.88	851.18
LAG540147	AUCOIN'S SEWER UTILITY SERVICE	12,000 GPD RESIDENTIAL STP	9.38	4255.90
LAG540154	AUCOIN'S SEWER UTILITY SERVICE	18,000 GPD RESIDENTIAL STP	9.38	4255.90
LAG540155	AUCOIN'S SEWER UTILITY SERVICE	17,600 GPD RESIDENTIAL STP	9.38	4255.90
LAG540185	BOB DEAN ENTERPRISES INC	SEWERAGE PLANT	9.38	4255.90
LAG540364	HOUSING AUTHORITY OF LAFOURCHE PH	STP	9.38	4255.90
LAG540454	LAFOURCHE PAR SCH BD	PUBLIC SCHOOL	9.38	4255.90
LAG540460	LAFOURCHE PH SCH BD	PUBLIC SCH	9.38	4255.90
LAG540463	LAFOURCHE PARISH SCHOOL BOARD	SEWERAGE	9.38	4255.90
LAG540498	COMMERCIAL PROPERTIES DEV CORP	SEWERAGE PLANT	9.38	4255.90
LAG540852	MCDONALDS CORP THIBODAUX	FAST FOOD RESTAURANT	9.38	4255.90
LAG540861	LAFOURCHE PARISH RECREATION DIST #2	SEWERAGE PLANT	9.38	4255.90
LAG540953	ROGERS TRAILER PARK	OXIDATION POND	9.38	4255.90
LAG560027	AUCOIN'S SEWER UTILITY SERVICE	RESIDENTIAL STP	18.77	8511.80
LAG560032	AUCOIN'S SEWER UTILITY SERVICES	35,200 GPD (2) MECH. STPS	18.77	8511.80
LAG560112	LAFOURCHE PH SCH BD	PUBLIC SCH	18.77	8511.80
LAG750171	JOEY'S CAR WASH	CAR WASH	1.32	600.93
LAG75018	HILL CITY OIL CO INC	SERVICE STATION	1.32	600.93
LAG750203	ABCD REALITY INC	CAR WASH	1.32	600.93
LAG750234	ARABIE TRUCKING CO	VEHICLE REPAIR	1.32	600.93
LAG750253	BOLOTTE CARWASH	CAR WASH	1.32	600.93
WP0838	J R ENTERPRISES	CAR WASH	1.32	600.93
WP2236	MR BTS MOBILE HOME PARK	SEWERAGE PLANT	0.45	204.28

(1) WLA for LA0107174 (Pelts & Skins Export LTD) is seasonal and is included in summer season TMDL only.
lbs/day = pounds per day
g/day = gallons per day

6.2 Nutrient TMDL

Louisiana has no numeric nutrient standards for waterbodies but does have a narrative standard which requires that the naturally occurring range of nitrogen-phosphorus ratios be maintained. For the purpose of this TMDL, nutrients included total nitrogen (organic nitrogen, ammonia nitrogen, and nitrite plus nitrate nitrogen) and total phosphorus (TP). An evaluation of the nutrient ratio was performed on water quality data from the Bayou Lafourche monitoring stations. The calculated ratio was determined to be about 11:1. This ratio is supported by available reference stream data for the Upper Mississippi Alluvial Plain and South Central Plain ecoregions of 10:1 (Smythe, 1999).

6.3 Ammonia Toxicity Calculations

Although Subsegment 020401 is not on the 303(d) List for ammonia, the ammonia concentrations predicted by the projection model were checked to make sure that they did not exceed EPA criteria for ammonia toxicity (EPA 1999). The EPA chronic criterion (Criterion Continuous Concentration) is dependent on temperature and pH. The water temperature used to calculate the ammonia chronic toxicity criterion for Bayou Lafourche was the same as the 90th percentile temperature used in the projection simulation (30.27°C).

For pH, an average of the values measured at LDEQ monitoring stations on the subsegment during the calibration period was used (pH = 7.62). The resulting criterion was 1.44 mg/L of ammonia nitrogen. The instream ammonia nitrogen concentration predicted by the LA-QUAL model, 0.14 mg/L, was well below the criterion. The low concentration indicates that the ammonia nitrogen loadings that will maintain the DO standard are low enough that the EPA ammonia chronic toxicity criterion will not be exceeded under critical conditions.

6.4 Other Hypothetical TMDL Scenarios

The modification of nonpoint source loadings under Scenario 3 was accomplished under Scenario 2 in which nonpoint sources were increased to determine the additional assimilative capacity in the subsegment beyond current loadings.

The hypothetical TMDL projections for Scenario 4 (modified flow scenario) were based on two flow regimes: a minimum flow that maintains the 5.0 mg/L DO standard (Scenario 4a) and a maximum anticipated flow of 1,000 cfs (Scenario 4b). At fully permitted point source and nonpoint source loading, a minimum flow of 2.1 cfs was determined to be the minimum flow necessary to maintain the 5.0 mg/L DO standard in summer. The 5.0 mg/L DO standard would be maintained in winter even at zero flow. The resulting hypothetical TMDL projection summary is provided in Table 6.3 below. These results are largely due to reaeration being fixed at a measured rate and were not a function of velocity or depth. Consequently, they may not be reliable.

Table 6.3
Hypothetical TMDL (sum of $CBOD_u$ and $NBOD_u$)
Under Scenario 4a for Subsegment 020401
(Bayou Lafourche from Donaldsonville to the ICWW in Larose)

Load Description	Summer (May-Oct)	Winter (Nov-April)
Current Point Source Loadings at Critical Conditions (kg/d of UOD)	533	396
Current Nonpoint Source Loadings at Critical Conditions (kg/d of UOD)	3,053	3,053
Maximum Point Source Loadings at Critical Conditions (kg/d of UOD)	533	396
Maximum Nonpoint Source Loadings at Critical Conditions (kg/d of UOD)	835	810
Point Source WLA (kg/d of UOD)	533	396
Nonpoint Source LA (kg/d) of UOD	835	810
MOS (kg/d of UOD)	0	0
Assimilative Capacity (kg/d of UOD)	1,368	1,206
Reserve Capacity (kg/d of UOD)	0	0
TMDL (kg/d of UOD)	1,368	1,206
TMDL (lbs/d of UOD)	3,015	2,658
% Reduction in Nonpoint Source Loadings Required:	NA	NA
% Reduction in Point Source Loadings Required:	NA	NA

kg/d = kilogram per day
lbs/d = pounds per day
UOD = sum of $CBOD_u$ and $NBOD_u$

At the maximum anticipated diversionary flow of 1,000 cfs and removal of the weir at Thibodaux, no load reductions were required for summer critical conditions (7Q10 flow and temperature of 30.27°C) or for winter critical conditions (7Q10 flow and temperature of 20.80°C) in order to maintain the 5.0 mg/L DO standard. An explicit 10 percent margin of safety was included in the TMDL calculations. A summary of the hypothetical TMDL projection for DO is provided in Table 6.4 below.

Table 6.4
Hypothetical TMDL (sum of $CBOD_u$ and $NBOD_u$)
Under Scenario 4b for Subsegment 020401
(Bayou Lafourche from Donaldsonville to the ICWW in Larose)

Load Description	Summer (May-Oct)	Winter (Nov-April)
Current Point Source Loadings at Critical Conditions (kg/d of UOD)	533	396
Current Nonpoint Source Loadings at Critical Conditions (kg/d of UOD)	3,053	3,053
Maximum Point Source Loadings at Critical Conditions (kg/d of UOD)	533	396
Maximum Nonpoint Source Loadings at Critical Conditions (kg/d of UOD)	108,666	157,786
Point Source WLA (kg/d of UOD)	533	396
Nonpoint Source LA (kg/d of UOD)	97,746	141,968
MOS (kg/d of UOD)	10,920	15,818
Assimilative Capacity (kg/d of UOD)	109,199	158,181
Reserve Capacity (kg/d of UOD)	94,693	138,915
TMDL (kg/d of UOD)	109,199	158,181
TMDL (lbs/d of UOD)	240,739	348,724
% Reduction in Nonpoint Source Loadings Required:	NA	NA
% Reduction in Point Source Loadings Required:	NA	NA

kg/d = kilogram per day
lbs/d = pounds per day
UOD = sum of $CBOD_u$ and $NBOD_u$

Much of coastal Louisiana was built by the process of delta formation through flooding and deposition of sediments by the rise and fall of the Mississippi River. Based on EPA's present knowledge, extensive areas of wetlands and coastal marshes are affected by a high rate of subsidence and degradation, primarily due to a lack of historical sediment and nutrients entering the wetlands. Subsidence is a natural process, but the building of levee systems has restricted the Mississippi River's course therefore preventing the natural cycle of the river and the natural process of delta formation. According to EPA, a large portion of the state's coastal wetlands have undergone and continue to undergo a severe deprivation of sediments and nutrients that has led quite literally to the breakup of the natural system. In addition, EPA believes that many of Louisiana's wetlands have become isolated from the riverine sources that created them and are becoming stagnant and starved for nutrients and organic and inorganic sediments. It should be pointed out that restoration of these eroding wetlands involves supplying nutrients to these wetlands through managed Mississippi River diversions.

The proposed TMDL for DO and nutrients for Bayou Lafourche presents a modified flow scenario, Model Scenario 4b. The modified flow of a 1,000 cfs diversion from the Mississippi River into Bayou Lafourche resulted in no required load reductions to maintain 5 mg/L of DO during summer and winter critical conditions as reported in Section 4. The Bayou Lafourche reintroduction proposed under the Louisiana Coastal Area, Louisiana, Ecosystem Restoration Study (LCA Study) could range from 1,000 to 5,000 cfs. EPA believes that flows greater than 1,000 cfs will result in flow increases that will enhance DO and decrease the likelihood of instream nutrient impairment in Bayou Lafourche. Based on EPA's calculations, if the proposed diversion from the Mississippi River into Bayou Lafourche approaches 5,000 cfs, the non-point source load allocation and TMDL for Model Scenario 4b will also be increased by 390,984 kg/day of UOD for the summer and 567,872 kg/day of UOD for the winter, respectively (EPA, 2005).

Based on EPA's current understanding, these diversion projects are supported by both State and Federal agencies, including EPA and the U.S. Army Corps of Engineers. The diversions are managed by the Corps of Engineers and the State, and the projects include post-diversion monitoring to determine effectiveness of the project and to monitor water quality conditions.

7.0 OTHER RELEVANT INFORMATION

This TMDL for Bayou Lafourche has been developed to be consistent with the antidegradation policy in the LDEQ water quality standards (LAC 33:IX.l 109.A).

Although not required by this TMDL, LDEQ utilizes funds under Section 106 of the Federal Clean Water Act and under the authority of the Louisiana Environmental Quality Act to operate an established program for monitoring the quality of the state's surface waters. The LDEQ Surveillance Section collects surface water samples at various locations, utilizing appropriate sampling methods and procedures for ensuring the quality of the data collected. The objectives of the surface water monitoring program are to determine the quality of the State's surface waters, to develop a long-term database for water quality trend analysis, and to monitor the effectiveness of pollution controls. The data obtained through the surface water monitoring program are used to develop the State's biennial 305(b) report (Water Quality Inventory) and the 303(d) List of impaired waters. This information is also utilized in establishing priorities for the LDEQ nonpoint source program.

LDEQ has implemented a watershed approach to surface water quality monitoring. Through this approach, the entire state is sampled over a 4-year cycle. Sampling is conducted on a monthly basis or more frequently if necessary to yield at least 12 samples per site each year. Sampling sites are located where they are considered to be representative of the waterbody. Under the current monitoring schedule, targeted basins follow the TMDL priorities. In this manner, the first TMDLs will have been implemented by the time the first priority basins will be monitored again in the second 4-year cycle. This will allow LDEQ to determine whether there has been any improvement in water quality following establishment of the TMDLs. As the monitoring results are evaluated at the end of each year, waterbodies may be added to or removed from the 303(d) List.

8.0 PUBLIC PARTICIPATION

After completion of a draft TMDL, EPA prepared a notice seeking comments, information, and data from the general public and affected public. Comments, data, and information submitted during the public comment period are included in Attachment A (Responses to Comments are shown in italics). This final TMDL was revised considering public comment, information, and data, and will be transmitted to the Louisiana Department of Environmental Quality (LDEQ) for incorporation into the LDEQ current water quality management plan.

9.0 REFERENCES

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